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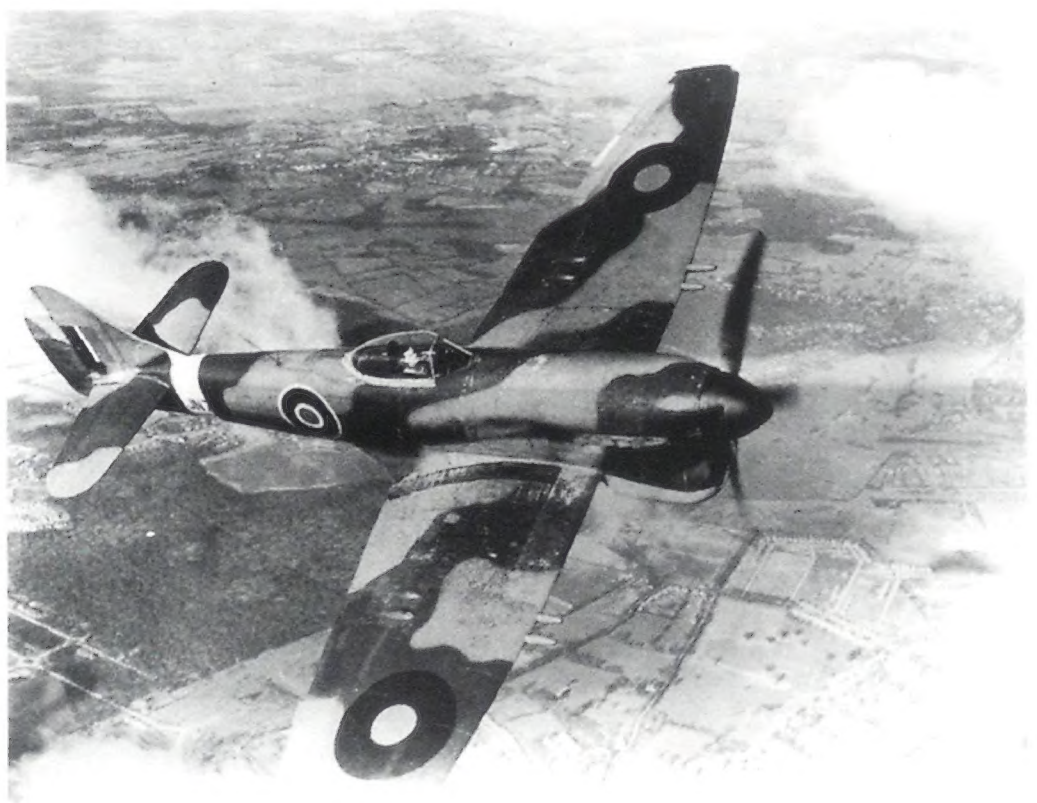

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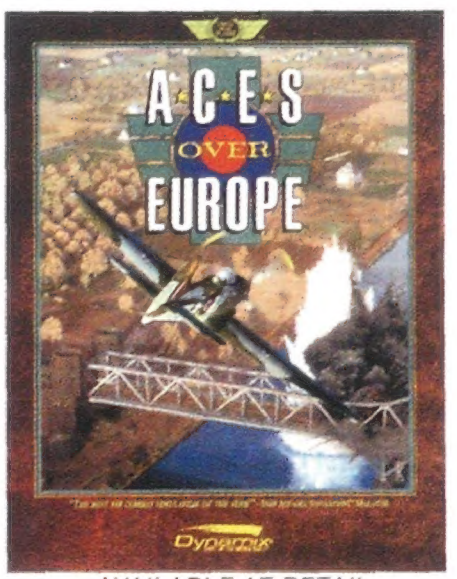

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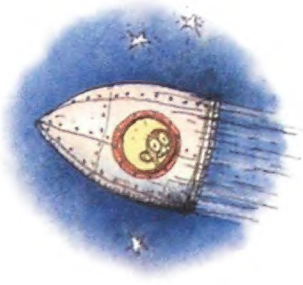
Special Graphic Supplement
This series of often radical craft has taught us how to fly higher, faster, farther, and sometimes just...differently.



Cover:
A Martin Mars demonstrates its firefighting capability for photographer Phil Schofield.

Departments

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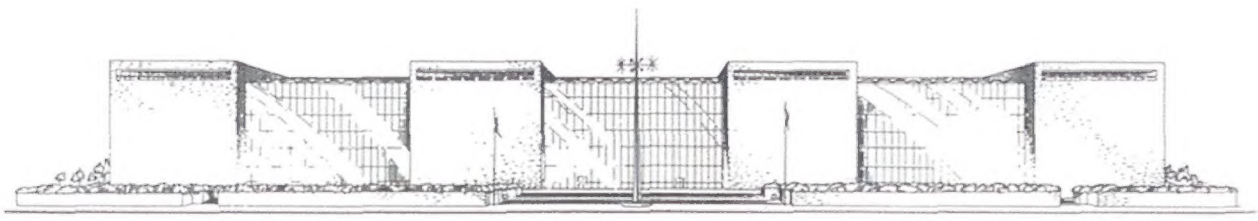

Learning From Failure

Nobody ever thought that space exploration could be free of risk. Nor is it unusual, in any complex enterprise, to have a string of failures. But when that string becomes too long and the accumulation of failures too costly, reasonable people will ask for an objective investigation—not a witch hunt, but rather an attempt to learn from failure and come away stronger.

The problems encountered with the Hubble Space Telescope, the Galileo mission, the recently launched weather satellite NOAA-13, and now the Mars Observer constitute such a series.

Maybe we are being too ambitious or have lost track of certain basics. Or perhaps our missions are more failure-prone because the easy problems were tackled long ago, in the 1960s and 1970s. By the 1980s the preliminary reconnaissance of previously inaccessible domains of nature had been accomplished, and we were ready for more intensive investigations. Demands for sophisticated missions devoted to astronomy, space exploration, planetary studies, and Earth monitoring began to steadily mount.

Such projects can be carried out only with increasingly complex, state-of-the-art instrumentation. And as costs mount, while the real purchasing power of NASA funding has remained roughly constant, the frequency with which major new spacecraft can be launched has declined dramatically, to the point where scientists accustomed to one spacecraft launch a year in the 1960s now are permitted no more than one launch per decade.

In response to these declining launch rates, researchers pack ever greater capabilities into each payload, mindful that it could well be the last opportunity for a long time to come.

Such an approach invites disaster.

Space efforts have proved most reliable when we fly the same equipment over and over again. Clearly that is not possible when each new mission has entirely new objectives; but certain compromises are still possible and increasingly necessary.

Every mission can be broken down into four key components: (1) mission-specific instruments, usually one of a kind, designed for the unique objectives that lie at the heart of the mission, (2) support equipment, such as solar panels, attitude controls, transmitters, and antennas, which could be used on a variety of different missions, (3) launch and insertion into a desired orbit, and (4) mission operations and data analysis, which nowadays often entail the development of expensive software.

An ideal division of emphasis and expenditures among these four components may not exist, but spending roughly one-quarter of the mission's budget on each may not be a bad choice.

The recent failures tend to lie in the realm of support equipment, so it is worth remembering that success rests on absolute vigilance in standardizing such infrastructure, to the point of accepting tried-and-true equipment that has seen many previous successful spaceflights, even if it is bulkier and more massive than newer components and requires sacrifices in the weight or power available for the mission-specific instrumentation.

Though they have not received much coverage in the press, the attitude gyros on recent missions have been notoriously unreliable. Virtually every sophisticated spacecraft requiring three-axis stabilization has had its share of problems, including the Hubble Space Telescope. And without reliable attitude controls, transmitters, antennas, and solar panels, it makes little sense to launch complex, mission-specific instruments that depend on such basics for support.

When the cost of mission-specific instrumentation far outstrips that of support equipment, or launch and orbit insertion, or mission operations and data analysis, it may make more sense to go for simpler, more frequent missions.

We may have violated those precepts. It may be worth taking a look.

—Martin Harwit is the director of the National Air and Space Museum.

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LETTERS

The Story Behind the Story

In the June/July 1993 Flights & Fancy ("Random Sightings") I read a short item about a secret NASA satellite finding evidence that heaven is a real place. You are always so factual; is this valid?

—*Lynn Bredeson*
Sumner, Washington

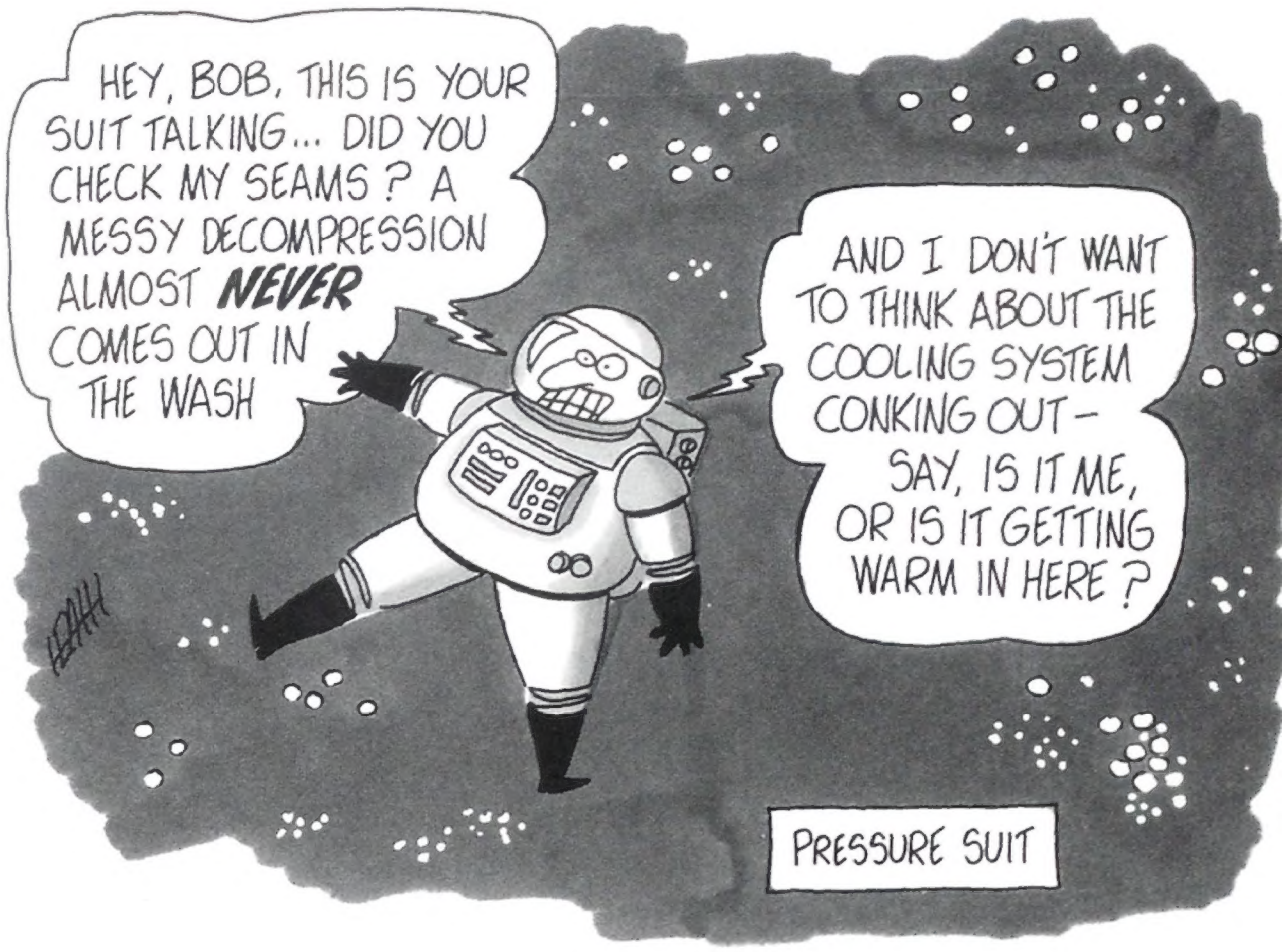
Editors' reply: Regular readers recognize the Flights & Fancy department as the section in which we have always published light, amusing, or fanciful fare. Usually the department consists of a single article; occasionally, we round up a number of short items and publish them under the title "Random Sightings." All of these items did in fact first appear, exactly as written, in the publications indicated. Beyond that, we cannot vouch for their truthfulness.

The entry you asked about was taken from the Weekly World News, *perhaps the most creative of the supermarket tabloids. One recent issue included a story titled "Move Over, Rover! 2-foot roaches replacing dogs as man's best friend, say scientists!"*

Towing Woes

Linda Shiner's "The High Sign" (August/September 1993) was enjoyable, but it made no mention of the hazards that banner towing creates in low altitudes. The following example gave me a few gray hairs.

The day General Eisenhower returned from World War II to Chicago in 1946, a parade was scheduled to march down Michigan Boulevard. I led a flight of six A-26Bs in an 18-bomber formation that was to do a flyover of the parade. The formation joined up over Selfridge Air Force Base at Detroit. As the leader climbed to 2,000 feet, I got my "low flight" into position, below and to the left of the lead flight. Somewhere between Ann Arbor and Jackson I heard excited voices



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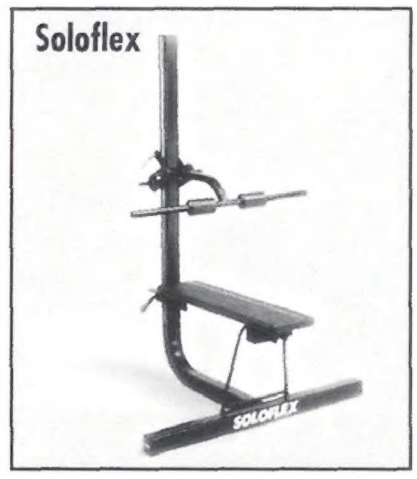

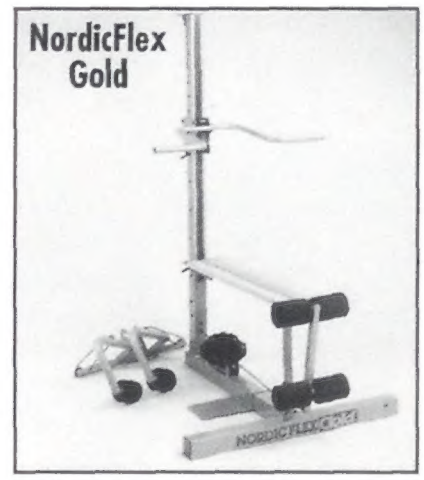

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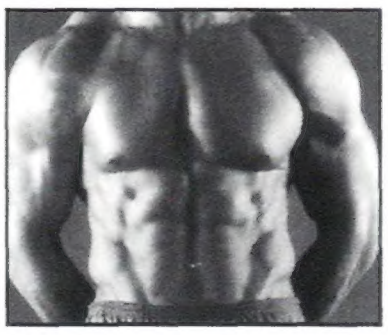

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on our radio and saw the lead flight do an undesirable steep left turn (into my relative position). I hauled off power and watched my wingmen struggle to stay in position. Then out of the corner of my eye I saw a yellow Stearman flash by towing a banner that read "EAT SHAFFER'S WHOLEWHEAT BISCUITS."

On return to Selfridge later that day my right-hand wingman told me that the banner had probably cleared his vertical fin by about 20 feet. The "high sign guy" had gone right through our formation at about 90 degrees to our flight direction.

—Carl Oates
Ashland, Oregon

A Tell-Tale Influence?

In addition to perpetrating his own balloon hoax, Edgar Allan Poe may have been indirectly responsible for the Richard Adams Locke moon deception your article "The Tell-Tale Hoax" (August/September 1993) also mentions. In *Literati of New York City*, a collection of magazine profiles of New York writers, Poe suggests that his short story "The Unparalleled Adventures of One Hans Pfaal" may have been the inspiration for Locke's tale of the discovery of winged human-like creatures on the moon. "Hans Pfaal" is about a balloon trip to the moon; it was published in June 1835, only two months before Locke's moon hoax appeared.

—T. Patrick Coulehan
North Ridgeville, Ohio

*Editors' reply: We passed your theory by biographer Kenneth Silverman (*Edgar A. Poe: Mournful and Never-Ending Rembrance, *HarperCollins, 1991). First noting that "Poe was constantly accusing other people of plagiarism; indeed, he made a career out of it," Silverman went on to point out that Locke had much contemporary moon literature to draw on, "in fact, all the contemporary material that Poe himself had and used." Locke's hoax, said Silverman, "contains no verbal or structural parallels to 'Pfaal' that might indicate that his inspiration came from Poe, rather than from the same events and publications that inspired Poe himself."*

Disappointed With NASA

In "Battle of the Big Shots" (August/September 1993) Bob Norwood of NASA's advanced concepts office says: "You can't just focus on the launcher; you've got to look at the economics of the entire mission model." Whoa! When did NASA get this divine piece of wisdom? Before or after they came up with the shuttle program?

Maybe they can use one of the launcher guns for emergencies. For example, when the shuttle's $30 million toilet goes kaput, they could shoot some plastic bags up.

—James G. Gill
Greenfield, Wisconsin

The Flyboys of Summer

"Outfield Fly" (Flights & Fancy, August/September 1993) brought back some 50-year-old memories. In October 1943 I was flying a B-24D from Topeka to Great Britain to join the Eighth Air Force. Our plane was named the *Missouri Mauler* because the four officers on the crew were all from Missouri. En route we made several stops. At the next to last we encountered four B-17 crews who were also on their way to Great Britain. We spent a happy evening with the crews arguing the merits of the B-17 versus the B-24. When we discovered some New Yorkers on the crews, the argument switched to the World Series, which was then in progress. We debated which was the better team, the St. Louis Cardinals or the New York Yankees. Before we turned in we agreed to continue our discussions at our next stop.

The next morning the four B-17s took off before we did. We finally left around noon. Dutch, our radio operator, picked up the ball game on the radio and we all listened in. Suddenly the announcer began shouting that the Air Forces were putting on a great show for the fans. Four B-17s were buzzing Yankee Stadium and the crowd was going wild. I almost fell out of my seat. I knew the men flying those planes! They were our new-found friends! Our whole crew started cheering them on. They all wanted me to catch up and join the fun but we were too far behind.

—Ralph Golubock
Dallas, Texas

Blackbird Redux

"Above the Sky" (August/September 1993) interested me a lot because making

UNIDENTIFIED FLYING OBJECT

Can you identify the aircraft in this photograph? From time to time the National Air and Space Museum receives photographs of objects that its archivists cannot identify. This fairly ordinary side-by-side two-seater looks like many of the late 1920s. It has a five-cylinder radial engine, ailerons only on the lower wings, and—somewhat unusual for the time—a tailwheel instead of a skid. (Don't be deceived by the missing portions of the airplane's upper wing and propeller; the archivists believe that's simply a goof in the way the original print was made.) The registration on the rudder appears to begin with "X," indicating "experimental" status. Nothing is known about the location or the people. If you can solve the mystery, write to: Letters, Air & Space/Smithsonian, *370 L'Enfant Promenade SW, 10th Floor, Washington, DC 20024.*

Eleven readers identified last issue's UFO, though they were unable to supply many details. A similar photo of the airplane, published in several books and dated January 22, 1914, identifies the location as Hollis, a neighborhood of Queens, New York. According to Queens, a Pictorial History *by Vincent F. Seyfried (The Donning Co., 1982), a barnstormer named Howard Huntington built the craft out of baby carriage wheels, rubber bands, and plywood. We have yet to learn whether the airplane ever managed to fly.*

a cold war machine into a scientific research plane is a really good idea. But what will happen to the SR-71 Blackbird? Is NASA going to use it in a similar way, or will the plane never be flown again?

—*Michael Nedeltscheff*
Sea Cliff, New York

Editors' reply: NASA has three SR-71s and does indeed plan to use them all as high-altitude research vehicles equipped with various sensors and telescopes.

Corrections

"At the Point of Singularity" (August/September 1993) misidentified the location of Lick Observatory. The facility is located on Mt. Hamilton, about 55 miles from Santa Cruz, California.

In "Remember Los Alamos" (Soundings, August/September 1993), the second sentence of the third paragraph should have read: "Some thought it ironic that Teller, now 85, played such a prominent role in the reunion, since it was Teller's testimony against Oppenheimer, the lab's first director, that many blamed for 'Oppie's' security clearance being revoked in the 1950s."

The correct name of the radar station described in "Doomed Domes" (Soundings, August/September 1993) is Fylingdales.

In the August/September 1993 In the Museum section, Jon Lomberg's painting of the Milky Way was inadvertently reproduced backwards.

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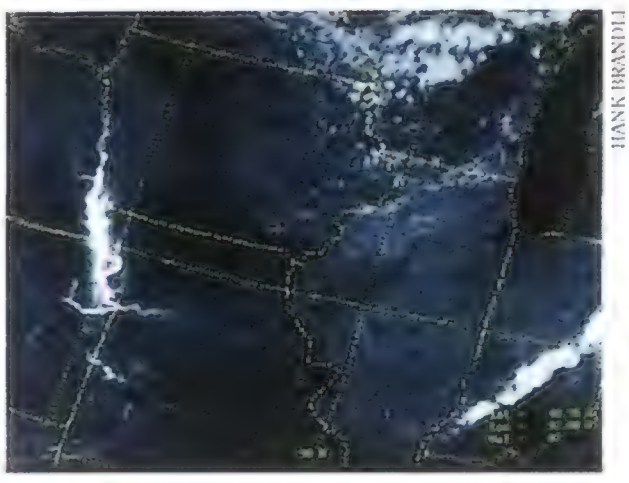
Over Troubled Water

KEVIN HORAN (2)



HANK BRANDLI

Sun glints off the flooded Missouri and Mississippi Rivers in a NOAA-11 weather satellite photo, while the locals take a new rush-hour transport to work.

It was hard to tell if Julie Aschemann was more nervous about running late for work or taking her first helicopter ride. "I've never been in one before," the X-ray technician confided. "And I'm pregnant!"

Aschemann was among the hundreds of commuters in Quincy, Illinois, stranded when levees along the swollen Mississippi broke last summer, wiping out highways and bridges along the 300-plus miles of river from Moline to St. Louis. After the Bayview Bridge was closed, the only way to get to a job across the river was aboard one of the airplanes or helicopters pressed into emergency shuttle service—a queasy situation for novice riders like Aschemann and a migraine for Jan Knipe, general manager of Heetco Jet Center at Quincy's Baldwin Field.

"The levee went in a blaze of fury on a Friday evening, and it was just as blazing around here," says Knipe, recounting how the July 16 dike failure loosened a barge that slammed into a fuel tank, setting gasoline—and his phone lines—on fire. "It was the damnedest thing I've ever seen. The phones went 24 hours, nonstop."

Knipe, a pilot and commuter airline veteran, went into a mad dash rounding up aircraft, operating clearances, and manpower for an emergency commuter service. By Monday morning five single- and twin-engine airplanes stood ready to run between Quincy and Hannibal, Missouri. But the flood of humanity proved as overwhelming as the river. "You can't imagine how jammed this place was," Knipe says. "People would do anything to get on a plane—lie, cheat, steal, even sell their own mother."

"It got pretty wild," confirms center manager Chris Michaels. "A private pilot stopped here to refuel, and when he got back to his plane it was full of people."

Knipe estimates he was initially moving 18 to 20 flights an hour and nearly 1,000 commuters a day—all this at an airport that normally handles no more than eight commuter and 20 general aviation flights daily. In addition to medical runs and inspection tours by government officials, the center's aircraft handled an unusual assortment of cargo. "Federal Express packages, newspapers, machine parts, dogs, cats—we carried everything but chickens," Knipe says.

By early August the Missouri National Guard had a temporary air traffic control tower in operation, though not for the commuter crush. It had been scheduled to open for the World Freefall Convention, a gathering of 2,000 skydivers who annually converge on Baldwin Field for a 10-day "boogie." The juxtaposition of National Guard trucks and helicopters, commuter airplanes coming and going like buses, and swarms of colorful parachutes floating over the Illinois cornfields was surreal.

The traffic jam at the airport prompted Knipe to widen his search for aerial help to include helicopters, which could take off from a makeshift site in town and land directly across the river. He got two Aerospatiale TwinStars from Air Center Helicopters, a Virgin Islands-based company that happened to be making an

IMAX movie in Missouri for a local theater opening.

The rides were $20 one way ($15 by airplane once the helicopters were in operation), which Knipe says was a break-even fee. Some companies picked up the tab for employees. There was also a steady stream of sightseers who wanted a look at flood-damaged areas. "We had to kick sightseers off the damned helicopters and give priority to medical people and commuters," Knipe says.

For all the confusion, even first-time fliers seemed to be enjoying the rides. "Most of them were amazed by the flooding," says Paul Fullerton, an air charter service owner who had brought his Piper Cherokee to Quincy to lend a hand. "I think seeing their neighbors' houses underwater diverted their attention and made them forget all about their fear of flying."

Julie Aschemann finally boarded a TwinStar with a purse in one hand and a camera in the other. The helicopter was like a limousine—carpeted, air conditioned, and soothingly quiet. It lifted up and out over the Mississippi and made a beeline for the opposite shore, submerged for seven miles inland. As half-sunken rooftops, trees, and gas stations sped by below, Aschemann clicked away like a kid on a class trip.

Less than four minutes later the pilot set down on a deserted stretch of Highway 24 outside Taylor, Missouri. The ground was covered with silt and a faint stench hung in the air, but Aschemann seemed not to notice. She spotted a car and yelled, "There's my ride!"

Asked about the helicopter, she said, "It was wonderful. It beats the plane all to heck. There was no nausea or anything." Take it from an expectant mom.

—Frank Kuznik

UPDATE

Banjul Bandits

A NASA team stationed at the Gambia's emergency landing site for a shuttle launch ("In Case of Emergency, Land at Banjul," February/March 1992) was forced to abandon the Kairaba Hotel in Banjul last July after four or five bandits wielding shotguns and machetes stormed the building. Some tourists were roughed up, but no NASA people were injured. Hotel security shot and killed one of the attackers. The NASA team flew to Brussels for a week, then returned to Banjul for a third launch attempt.

ANTONY PLATT

Lieutenant Commander Carl Murray undergoes a last-flight rite of passage at the Oceana Naval Air Station in Virginia as he exits a Douglas A-4 that is about to retire to the New Mexico desert. The VFC-12 adversary squadron, which has flown Skyhawks for 20 years as simulators for various MiG-series fighters, is moving up to the McDonnell Douglas F/A-18, along with the rest of the Navy. The dousing and a reunion of squadron members followed a 12-aircraft flyover last July 16.

Jet-in-a-Box

Jim Bede, the indefatigable aeronautical engineer who brought us the BD-1 (which became the American Yankee) through -9, is back in the news with the BD-10, a high-performance personal jet in do-it-yourself kit form.

Some 60 reporters, photographers, well-wishers, and desert rats were at California's Mojave Airport last June for the first public flight of Bede's latest creation, a spectacle that lasted just a few minutes. Nonetheless, when the two-seat jet climbed out at 60 degrees and quickly turned into a dot, even jaded observers were impressed. "It should be illegal to put somebody in that airplane if they can't afford it," Bede told the crowd afterwards, "because it would hurt too bad."

This is not the first jet that Bede has designed for amateurs. In the 1970s his reputation took a nosedive with the BD-5, a revolutionary high-performance single-place aircraft originally designed around a two-stroke snowmobile engine. When the engine maker went bust in 1974, Bede was still able to persuade thousands to continue buying into the BD-5, purchasing bits and pieces as they became available. Meanwhile, the airplane, which had yet to complete a successful flight program, evolved on paper through beefier engines until it turned into a jet, the BD-5J. At about that time, Bede Aircraft closed its doors.

JORDAN COONRAD

That didn't stop warehouse-door manufacturer Frank Fulkerson from investing in a BD-10 in 1989, three years before the prototype took flight. He figures he'll spend "close to half a million when it's all done." But he isn't worried by the failure of the BD-5. "Oh, no," he says, "because I know what caused it."

Fulkerson says it was the failure of the engine manufacturer to deliver reliable powerplants that put Bede out of business in 1979, stranding thousands of BD-5 builders.

The BD-10, on the other hand, is designed around the General Electric CJ-610 turbojet, which has powered a number of business jets. According to Bede, there were some 18,000 of these engines produced, and though they are no longer made, they are readily available through GE's Kansas overhaul facility for about $100,000. With the engine situation seemingly under control, Bede has delivered six kits in addition to Fulkerson's and has received deposits for six more at a total price of $221,000 each. But there's no telling when any will be flying.

"One thing I want to make clear right now," Bede told the crowd at Mojave, "is that we have no idea how long it's going to take someone to build." He then offered a breathless analogy on how long it takes to barbecue a steak and added, "So man-hours are indefinable and it really doesn't make any difference."

Bede said that operating costs are practically negligible, if you don't count replacing the engine, which has a service life of 5,000 hours. Cruising at Mach .9, you'll be covering a lot of ground in each of those hours, he said, "so it's just fuel and maintenance. This airplane should not be any higher to operate and maintain than a [Beechcraft] Bonanza. I would say, fairly nicely, in the neighborhood of $150 to $200 an hour."

According to Bede, the BD-10 is also no more difficult to fly than a Bonanza. "I was thinking that if a person had a multi-engine or instrument license, then he'd already have enough discipline and experience to fly this," Bede said. "Some people have said we could take a Cessna pilot and, with just some basic training, do it." Regardless, the Bede Jet Corporation is developing a 25-hour flight course. "It's not so much how to fly the plane as how to navigate," said Bede. "You're going to get there three times faster and you're going to have to learn how to flip those knobs real fast as you go through one VOR [ground-based navigation station] after another."

It took a moment for everyone to start laughing with him. "All right, all right," he said. "I exaggerate."

—Elaine de Man

UPDATE

Quieter Flight-Seeing

Hawaii's largest aerial tour service has begun flying a new McDonnell Douglas MD 520N helicopter in an attempt to reduce noise ("The Battle Over the Rim," October/November 1992). Instead of a noisy tail rotor, the 520N has a fan in its fuselage to generate anti-torque thrust and directional control.

Temporarily Out of Service

Forget about spy-shy absentee Americans at the Paris Airshow last June. The real dropout was the Concorde—or what's left of it.

For the first time in 20 years, visitors to Le Bourget airport couldn't see a prototype of the Air France/British Airways supersonic transport, which has been on display at the Musée de l'Air since 1973. Number 001, which first flew on March 2, 1969, and racked up 397 test flights, is closed for repairs. It has spent its entire life outside, prey to wind, rain, and vandals, who have absconded with

supersonic souvenirs like altimeters and wing lights. Its cabin is speckled with corrosion.

"It's been washed, but there's been practically no maintenance," says Jean-Jacques Fouché, director of the museum's Concorde restoration project. "We just don't have the money."

Tourists who snatch Concorde parts also come away with a vision of a once mystical but now mangy airplane. This doesn't help one's image of grandeur. "Concorde is mythical, and that myth mustn't be destroyed by people seeing it this way," says Philippe Fluzin, who heads a $200,000 how-to-fix-it effort. "Unfortunately," he concedes, "that damage has already been done." However, Fluzin says the Concorde's wounds are only skin deep. "We found birds' nests in the fins," he says, "but the backbone is in amazingly good shape."

Restoration will be tough, due to the transport's aluminum- and titanium-based alloys. "But there's no point in restoring it if we don't cover it," Fouché insists, an extra he prices at about $1 million. Officials want the prototype ship-shape for a 1996 exhibit that will mark the 20th anniversary of the Concorde's first commercial flights. The revamped prototype will still be out in the parking lot, but at least it will have a roof over its head.

—Joshua Jampol

STEPHEN EBERSOLE

A Run for the Money

On a Sunday morning last July, the National Space Society held its first Race for Space in Washington, D.C. The event had a certain irony: runners puffing and sweating on Earth to help keep humans and hardware in space.

More than 1,000 runners participated in the five-kilometer competition, which was followed by a one-kilometer "fun run." The race and attendant hoopla, including prizes, spacesuit demonstrations, and the Nuclear Diode Robot Band, was aimed at fostering enthusiasm for the space program. In addition, entry fees raised more than $10,000 for the society's mission—"to educate the public on the importance of space exploration and development."

The race marked the 24th anniversary of the first manned lunar landing, and Apollo 11 astronaut Buzz Aldrin was honorary chairman. When Aldrin and Neil Armstrong first walked on the moon, amid vast national pride and international acclaim, few could have imagined a time when the space program would need robot musicians to help shore up public support.

Yet here was Aldrin defending the NASA budget, and NASA administrator Dan Goldin proclaiming, "This will be the last year we're going to debate the space station, because we're

going to get on with it." Both Goldin and Aldrin ran in the race, and Goldin told the crowd, "A lot of people said they had a couple of objectives. Objective one was to finish. Objective two was to beat Dan Goldin. There were a lot of very successful people today."

Prizes went not only to the fleet but also to the colorful. One winner was Malcolm Forbes. Isn't he better known for boats and hot-air balloons than for foot races? And isn't he, uh, dead? Well, *this* Malcolm Forbes, a distant relative of the famous publisher, is one year old, and he won in the category of Best Looking Legs.

—Lester A. Reingold

UPDATE

Departures

Test pilot Milton O. Thompson ("Fast Track," June/July 1993) died at age 67 in Lancaster, California, on August 6. He was to be the guest of honor at a dinner that evening acknowledging his accomplishments.

Timothy J. Brown, president of the International Council of Air Shows and owner of the National Airshows performing company ("Now Playing at an Airport Near You," April/May 1993), died August 9 when an L-39 jet trainer he was evaluating in the Republic of Kyrgyzstan crashed. The decorated combat pilot and Vietnam veteran was 49.

Cosmic Junk Mail

The company that emblazoned Arnold Schwarzenegger's *Last Action Hero* movie logo on a NASA-funded rocket that never flew (Soundings, April/May 1993) wants to launch advertising to new heights on a mile-wide satellite.

Astronomers and environmental and consumer groups went ballistic last April when Space Marketing in suburban Atlanta announced plans to have the huge sign up in time for the 1996 Summer Olympics. Congress is already pondering whether to make advertising in space a federal crime.

A company news release enticed prospective advertisers to imagine attending the games and looking up to see a soft drink slogan "not on a blimp, not towed by an airplane, but actually orbiting in space, miles above the earth, and visible throughout the world with the naked eye."

CHAD SLATTERY

This 1946 Aeronca Chief got its imaginative paint job in Arkansas in 1988, when Barry Sinex and Mark Courdin cast an F-15 likeness on the fuselage with a high-power projector, traced the outline, and filled in the details. The airplane was later sold to an F/A-18 pilot in California who enjoyed telling onlookers that his really neat paint job made his F-15 look like an Aeronca. Its present owner, Joe Langford, an Airborne Express pilot in Visalia, California, says line personnel like to tease him by asking if he needs kerosene fuel.

Astronomer Carl Sagan condemned the proposal as "an abomination." Consumer advocate Ralph Nader decried it as a "crass, audacious" marketing trick with "no remote control to turn this one off."

Astronomers fear that a billboard—or the twinkly shreds of one remaining after a micrometeorite or orbital debris encounter—will render the sky too bright for telescopes. "We face a very serious challenge to sustained deep-sky studies," says British astronomer Derek McNally, chairman of an environmental committee for the United Nations International Council of Scientific Unions. "I'm trying to imagine what it would be like to walk on the beach to watch the sunset and see a beer ad right there on the horizon," says Ed Johnson of the Public Interest Research Group, one of at least a dozen organizations mounting a "Save Our Skies" campaign to ban space billboards.

Apparently not everyone has the same aesthetic concerns. Space Marketing president Mike Lawson says that at least five major corporations are interested, but he wouldn't identify the companies willing to pay $15 to $30 million, plus launch costs, to rent space on a billboard that would appear roughly the size of the full moon.

The satellite, made of reflective Mylar plastic film and orbiting at 186 miles, would be invisible at night. It would shine brightest at sunrise and sunset. Traveling five miles a second, it would circle the globe every 90 minutes and remain in orbit for about three weeks before falling into the atmosphere and vaporizing. Viewed on Earth, a trip from horizon to horizon would take about 10 minutes.

NASA has nothing to do with the plan, but agency spokesman Charles Redmond told Reuters News Service: "If there's something American companies can do to make money in space, we're for it."

—Beth Dickey

UPDATE

Tilt-Wing Canceled

The Ishida Aerospace Research Group in Fort Worth, Texas, has canceled its plans to build the TW-68, a four-engine vertical-takeoff-and-landing tilt-wing commuter aircraft (Soundings, October/November 1992). Ishida announced last June that it has been unable to find manufacturing partners and therefore can't form a consortium to produce the $7 million tilt-wing.

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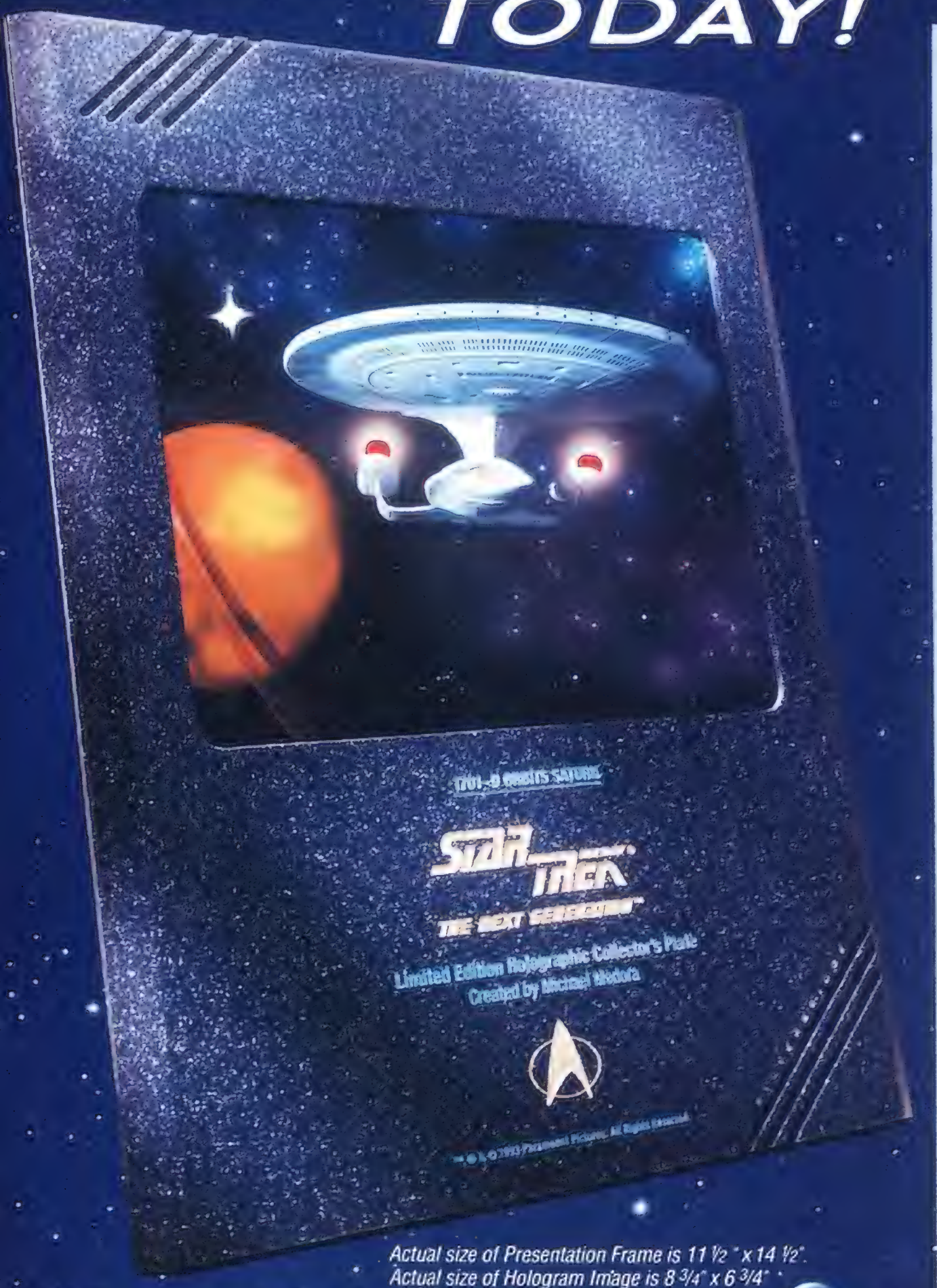

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UPDATE

Venus Probe Aerobrakes

The Magellan probe orbiting Venus circularized and lowered its orbit by aerobraking last summer ("Venus on a Shoestring," February/March 1990). The maneuver required Magellan to repeatedly drag itself in and out of Venus' upper atmosphere for two months. Project manager Douglas Griffith at the Jet Propulsion Laboratory in Pasadena, California, called it "a true first for planetary science."

The Return of Biggles

Forget the New Man. Forget the anti-hero. The epitome of the stiff upper lip Englishman is making a comeback.

The fictional British flying ace Biggles—Flight Lieutenant James Bigglesworth of the Royal Flying Corps—is being celebrated with reprints of his stories, exhibitions, air displays, and seminars during the 100th anniversary of the birth of his creator, Captain William E Johns. The embodiment of the gentleman player, Biggles, who saw his heyday in the 1930s, was a cross between Dick Tracy and Indiana Jones, with a British pedigree, a strong sense of chivalry, and a slightly anti-intellectual outlook. Johns drew on his own experiences as a World War I flier "to demonstrate to those unfamiliar with war flying history what

COURTESY RED FOX

amazing things could and did happen…more for the entertainment of the younger generation than the hard-baked warrior."

Johns left the trenches to volunteer for the Royal Flying Corps in 1917. Promoted to officer after receiving his wings, he was shot down in September 1918 after a lone battle with a squadron of Fokker D.VIIs. He left the air force in 1927 to make a modest living as a watercolor artist. In 1932, as the editor of *Popular Flying,* he published "The White Fokker," the first of his flying stories and an instant hit.

Over a 40-year span Johns wrote over 100 Biggles books. Each developed the character, taking him to the South American jungle, across the African deserts, and into an Interpol-like body, the Special Air Police.

Johns died in 1982. When the estate offered the reprint rights to the Random House imprint Red Fox, the publishers "snapped them up," says senior editor Caroline Thomas. "They are the perfect adventure stories in the genre of rip-roaring adventure—strong characters, lots of action with the appeal of a series. And they have a terrific record."

But not everyone is a fan. Take the Welsh hill farmers, for example, whose farms lie underneath the flight paths that the Royal Air Force uses for low-level training. One shepherd, whose hut had become a marker for jet jockeys to light their afterburners, let his feelings be known with whitewash paint. One morning a flight roaring by at 50 feet and 400 mph glimpsed the message on his roof: "Piss Off, Biggles."

—Stephen Bloomfield

UPDATE

Son of HOTOL

Alan Bond's latest reusable launch vehicle, Skylon, employs landing gear and a rocket-assisted takeoff unit in lieu of the launch trolley needed to accelerate the British Aerospace Horizontal Takeoff and Landing craft, the vehicle Bond's engines were to power ("The HOTOL Man," December 1988/January 1989). Bond's company, Reaction Engines Limited, estimates the cost of a Skylon satellite launch at around $5.9 million, as opposed to $100 million or more for deployment by an expendable launcher.

Presto!

GEOFF CHESTER (2)

What's wrong with these pictures? Only the illusions they bring to mind: twinkling stars and a sunrise.

Imagine yourself sitting on a beach with lots of palm trees," says Museum astronomer Geoff Chester. "You have one of those nice, tall orange drinks in your hand. The kind with paper umbrellas in it. And the moon rises above the horizon. It looks very big. Later, when the moon is overhead, it looks much smaller. But it isn't really smaller," he says, "and that has nothing to do with the number of those drinks you've had. It's a trick of the mind."

The "moon illusion," the perception that the moon is bigger when it's close to the horizon, is one of the sky mirages that a new planetarium show, "Universe of Illusions," will help visitors see through. "We can show that the apparent size of the moon overhead is actually a couple of arc seconds larger than when it's on the horizon," says Chester. During the period of Earth's rotation when the moon appears to climb in the sky, the person observing the moon actually moves closer to it. Astronomers measuring the moon's apparent size with a telescope and micrometer find it a few microns larger at the zenith of its arc in the sky than at the horizon. "Universe of Illusions" will explain, among other things, why the moon seems larger when it's not.

The idea behind the show, which opens this month in the Museum's Albert Einstein planetarium, "is that almost nothing we see in the sky is what it seems to be at first," says planetarium director Jim Sharp. Every sunrise, after all, is an illusion—it's Earth's motion, not the sun's, that we see—as is every night sky full of stars that appear to twinkle. The show also tackles less commonly observed and less well understood illusions, such as gravitational lensing, a recently discovered phenomenon caused by a very dense object in the foreground of a telescope's field of view that distorts the light from distant objects. Says Sharp, "It can do such tricky things as split the image of a galaxy in half," making it seem as though there are two galaxies where there is really only one.

Along with optical and perceptual illusions, the show explains intellectual and conceptual ones. There are demonstrations that dispel the long-held belief that everything in the universe has

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CHAD SLATTERY

The wooden framework of a Hawker Hurricane's fuselage, enclosing a steel and aluminum skeleton, is a beautiful example of the English style of aircraft manufacture in the 1930s. The airplane's construction enabled it to absorb heavy damage and made it one of the RAF's star fighters in the Battle of Britain. The Hurricane was a hybrid—its wings were formed by the more modern monocoque technique, in which the metal skin is responsible for structural integrity as well as aerodynamic shape—and marks a transition between aircraft assembled by skilled laborers and those mass-produced. Work began on the Hurricane in 1988 at the Museum's Paul A. Garber restoration facility.

order and that the chaos sometimes observed is only a failure of the human mind to understand the order that is really there. The concept of a universe of order arose with ancient Babylonian astronomers, who found that if they carefully observed and recorded the motions of the planets, they could mathematically predict them. The assumption held sway until this century. "We now know that you can predict the motions of the planets for thousands of years," Sharp says, "but you can't predict them for billions of years."

The entire history of astronomical discovery has been the deciphering of one illusion after another, says Sharp. He compares astronomers to children at a magic show. "Every time the kids think they've solved a trick, the magician has another illusion to dazzle them," he says.

There will be free continuous showings of "Universe of Illusions" when it opens on Saturday, October 30.

Bringing Mohammed to the Mountain

At 3,649 pounds, the Hubble Space Telescope/Structural Dynamic Test Vehicle is one of the heaviest artifacts in the Museum. So when Jim Barcus, the Hubble repair project support officer at NASA's Goddard Space Flight Center, asked to borrow it, collections manager Amanda Young suggested visiting it instead. Barcus wanted to use the test vehicle in a rehearsal for astronauts who will repair the real Hubble in space (see "Reality Check," p. 34). "Why don't you just bring 'em down here?" Young suggested. "It'll save a lot of money."

One evening in July after closing time, crew members from mission STS-61 visited the Museum's Space Hall to practice with the only full-size model of the space telescope. They brought a replica of a Hubble magnetometer box, one of the items they'll replace when they give the real telescope its tune-up in December. A magnetometer relays information about the spacecraft's orientation.

CAROLYN RUSSO

Before the astronauts could practice replacing the Hubble's magnetometer box, they had to train in the vehicle that could take them to the top of the model, 42 feet off the ground. Collections manager Bill Reese checked out astronaut Tom Akers in the Museum's lift, and Akers showed the other members of his crew the subtleties of moving the cab and rotating the turret. The astronauts replaced the test vehicle's magnetometer box with the replica, undid the repair, and returned safely to Earth.

—Linda Shiner

Museum Calendar

Except where noted, no tickets or reservations are required. To find out more, call Smithsonian Information at (202) 357-2700; TTY: (202) 357-1729.

October 2 Monthly Sky Lecture on a topic of current interest in astronomy. Einstein Planetarium, 9:30 a.m.

October 8 New Exhibit: "Monitoring Amazonia From Space." On display in the Milestones of Flight gallery through March 1994, the exhibit demonstrates how modern satellite technology is being used to study one of the world's most complex ecosystems.

October 14 G.E. Aviation Lecture. Chuck Yeager returns to the Museum to share his experiences as one of the country's most acclaimed test pilots. Langley Theater, 7:30 p.m.

October 26 Special Aircraft Exhibition: The Arado 234B Blitz. The world's first operational jet bomber, the Arado will be on display in Gallery 104 until next October.

November 6 Monthly Sky Lecture on a topic of current interest in astronomy. Einstein Planetarium, 9:30 a.m.

November 18 G.E. Aviation Lecture: "Tactical Aviation Bombardment in World War II." Five pilots will discuss Allied and enemy tactics during the war. Langley Theater, 8 p.m.

Museum Visits For a free planning packet, write Smithsonian Information, Smithsonian Institution, Washington, DC 20560 or call (202) 357-2700. Daytime parking near the museums is limited; visitors are urged to use the Metrorail subway system.

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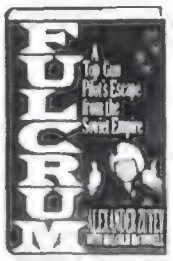

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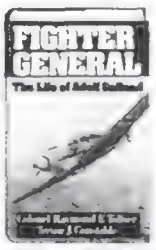

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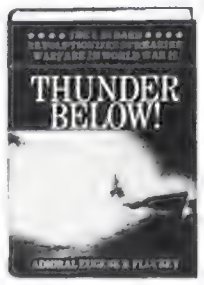

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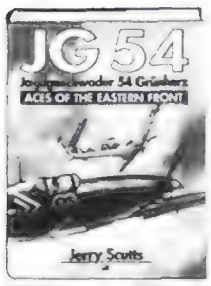

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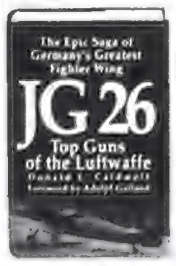

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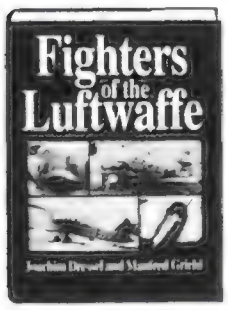

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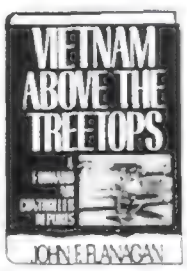

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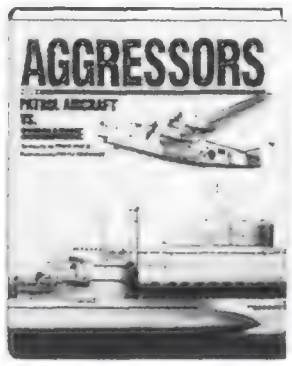

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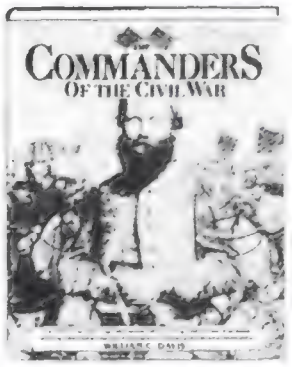

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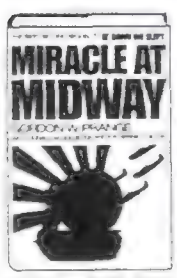

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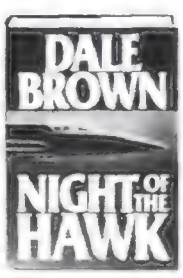

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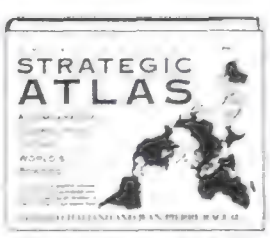

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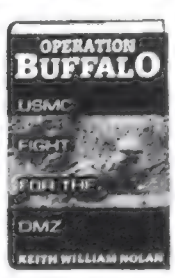

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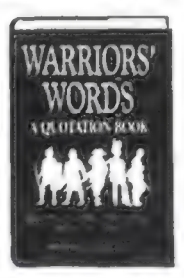

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THE UNKNOWN AIRMAN

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While I was on a business trip in April 1990 in Uherské Hradiste, Czechoslovakia, some associates from the LET aircraft company mentioned a monument they thought would interest me. In the tiny village of Velehrad, at an inconspicuous spot along the road, stood a 15-foot-tall stone and mortar monument with a plaque inscribed in Czech: "...In memory of an unknown American Airman who, on July 7, 1944, gave his life for his country."

I learned that on that date a B-17 bomber had crashed, and that most if not all of the crew had bailed out and had presumably been captured by the Germans. One body was found in the wreckage and the monument was later erected in his memory. There were fresh flowers at the site and wax from candles that had recently been burned.

My hosts pointed out that during the cold war people visited the monument at some peril, since they were liable to be questioned by the KGB. The Soviets were downplaying and in some cases denying the American presence in World War II. Apparently that did not prevent the locals from paying homage. Perhaps part of the reason for their reverence was the sparing of a medieval cathedral a half-mile away. Intentionally or not, the B-17 had unloaded its bombs over an unpopulated forest before it crashed.

Back home, I found myself thinking about the monument and what it stood for. The Czechs clearly held the airman's memory in high regard to have erected the monument in the first place and be maintaining it 46 years later. If he could be identified, the airman's kin could be told about the memorial. And surely the monument's caretakers would like to know who he was.

The American Legion and the Massachusetts Veterans of Foreign Wars put me in touch with the U.S. Army Prisoner of War/MIA office. They had no record of a B-17 lost on July 7, 1944, only a P-51. Thinking the airplane might have been a B-24 instead or that the date might be wrong, I asked the Czechs to verify the type. Not only was it a B-17, came the reply, it was a B-17G. The Army Mortuary Affairs office extended the search from July 2 to 16, but this also proved fruitless.

On my next trip, an associate gave me an old issue of the local paper that had a story about the crash and put me in touch with Frantisek Drinka, an eyewitness and a retired LET worker. In his apartment, over a bottle of homemade wine, he recounted what he saw. His story agreed with the newspaper account, which read:

"In the early morning hours of July 7, 1944, a formation of about 36 aircraft flew over the village of Velehrad. According to a radio broadcast they were heading for Vienna. Shortly afterward muffled explosions indicated that the area south of the village was being bombed. Afterward, a four-engine plane with its right engine on fire approached the village. It was attacked by two German fighter planes, which, after a few shots, retired from the area. The crew had parachuted from the plane shortly before the attack and landed in the vicinity of Nedekonice.

"The pilot directed the plane into the Chrib woods, where he discharged two bombs and then returned to the airspace above Velehrad. He possibly was already wounded and hadn't succeeded in directing the plane into the open space. The aircraft caught the tops of the trees and crashed into the forest one kilometer from our village. In crashing, the plane damaged about 200 meters of the wooded area, which was also set ablaze by the burning plane. The fire was quickly extinguished by the crew of local firefighters. After some difficulty with the German officials the pilot's body was properly buried in the local cemetery.

"On September 10, 1946, the grave was exhumed and the remains removed by the American Army. At the place of the crash a monument was built in 1945; it incorporated a few pieces of the plane wreckage and equipment. The downed aircraft was a Boeing B-17 'Flying Fortress.' The pilot was an American citizen. His name is recorded as Antonin Koleman."

I finally had a name. But no Anthony Koleman appeared in the military records, even under different spellings.

During my next trip I was discussing the airman with an associate when a LET employee who overheard us mentioned that her husband had been researching the air war over their country and might be able to help. He contacted a nearby aviation historian who had a document from the U.S. archives stating that the airman who was found in the wreckage was Staff Sergeant William J. Mack. He

also had copies of documents from the German archives that confirmed the name and date. Where the name Koleman came from was a mystery to him, since no such name was on either the crew list or a list of all airmen in the European theater. The Army archives undertook a search for information on Sergeant Mack.

About that time I heard from an ex-POW and B-17 crash survivor living near Washington, D.C., who had offered to search the National Archives. The archives had no record of a missing B-17, only the P-51, which was lost 50 miles north of Bratislava.

Mack's name, on the other hand, led to 30 pages of information—missing air crew reports, German Air Ministry reports, even a plot showing where in the Velehrad Cemetery Mack had been buried before being moved to an American cemetery in France. All this confirmed that the aircraft was a 15th Air Force B-17G, tail number 42 102889 (463rd Group, 774th Squadron), based in Italy. It had left from the Celone Army Air Base near Foggia to bomb the Blechhammer oil refinery. The reports basically confirmed what the Czechs had told me, except that Mack was the tail gunner, not the pilot. The files also noted that the radio operator had been wounded by multiple shell splinters. He and eight other crewmen of the 10-man crew survived, were taken prisoner, and, after some harrowing experiences, including a near-hanging in the Frankfurt rail station, were ultimately liberated and returned to duty. The P-51, which had the same destination and crashed in the same area, was probably flying cover.

According to the records Mack was married; his wife was living in Roanoke, Virginia, at the time. I was able to track her to Washington, D.C., but lost her after 1950. The records showed that his mother requested his remains be returned from France, and on April 25, 1949, he was interred in Arlington Cemetery in Elmhurst, Illinois. She had since died, but Mack did have a sister in Hampshire, Illinois, population 1,800.

Hoping that in such a small town everyone knew everyone else, I called the town hall. The town clerk, who was most understanding, made a discreet inquiry and found that Mack's sister did want to know about the monument.

She seemed comforted by my call. Now I wanted to let the Czechs know who the unknown airman was and that his next of kin was aware of their honoring his memory.

I thought that perhaps the remaining crew members, particularly the pilot, Edward Lindbloom, might also be interested. Armed with the crew list and their 1944 addresses, I tried to locate Lindbloom, but neither he nor the copilot, John Sant, was listed in the phone books. I had just about given up when my National Archives volunteer called: he had compared the crew list with a list from the Stalag 17 POW camp and had tracked down two of the crew who had been held there, waist gunner/engineer William E. Roberts and ball turret gunner Colonel Duncan. The American ex-POW Association found the current addresses of Lindbloom, Sant, and engineer/top turret gunner Harold Cruea, and the Army located waist gunner William Allen and radio operator Larry Shinnick (navigator John S. Beatty and bombardier Raymond Edgar had since died).

Through phone calls and letters I learned all the details of the flight. That morning, the B-17 was part of a flight of 36 flying in six formations. At 9:45 a.m., while the formations were still climbing, flak appeared, followed by about 30 Ju-88 fighter-bombers. Two came in on the right, out of the sun, knocking out the B-17's number three engine and wounding Shinnick. Cruea gave first aid to Shinnick and later helped him out the escape hatch. Mack was also seriously wounded. Roberts made two trips from his waist gun position to the tail gun position, initially to give Mack a shot of morphine and later to verify that he was dead.

The crew shot down three Ju-88s but could not keep up with the formation and began to lose altitude. A second engine was lost; Lindbloom was unable to feather either propeller. The bombs were jettisoned to lighten the load, but the aircraft was rapidly becoming uncontrollable. Lindbloom gave the order to bail out and set the autopilot on a course away from the village. He was the last to leave the aircraft, jumping at about 20,000 feet. At 10:10 a.m., a gunner in a nearby B-17 saw eight parachutes blossom under the stricken aircraft. He evidently missed seeing Shinnick, who had bailed out earlier.

After landing in a wheat field, Lindbloom, Sant, and Cruea were met by Czechs, who offered their clothing as a disguise. Concerned that they would be shot as spies if captured, the Americans declined.

The Germans rounded up all surviving crew members. Shinnick was sent to a hospital, the officers were sent to one POW camp, and the enlisted men were sent to another. Lindbloom and Sant tracked each other down after the war, but it was only after the unknown airman had been identified that the remaining crewmen were able to get in touch again. Most importantly, Lindbloom learned from Roberts the answer to the question that had plagued him for 46 years: that William J. Mack was indeed dead when Lindbloom ordered all to abandon ship.

—Norman J. Isler

On a Swing and a Prayer

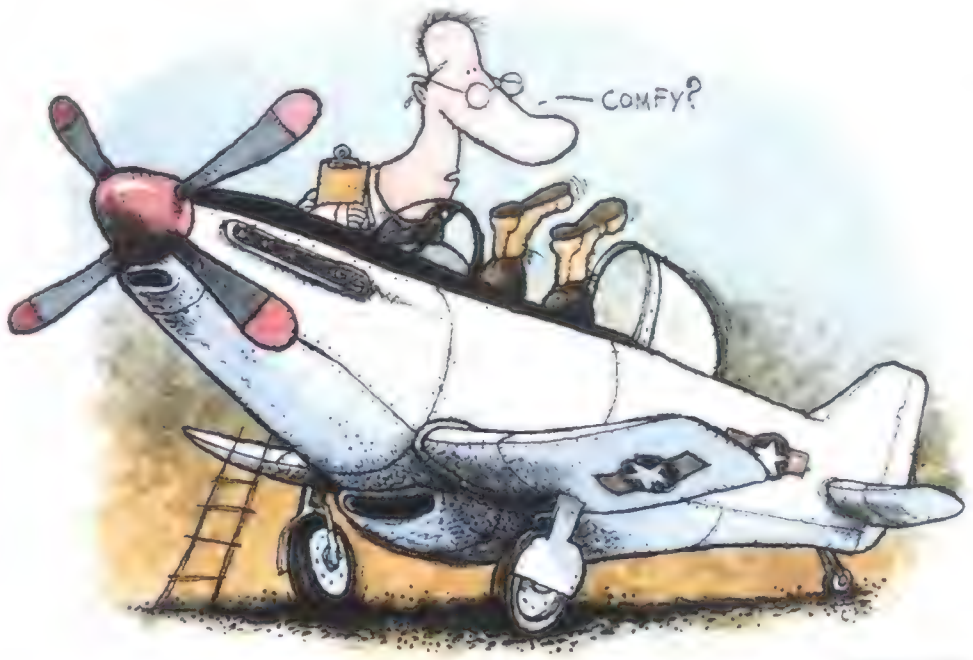
In the late 1950s I was assigned to the Air Proving Ground Command at Eglin Air Force Base in Florida as a test pilot in the Fighter Test Squadron. Our primary mission was evaluating new aircraft and their weapons, but occasionally we were called upon to test rather imaginative equipment as well.

One morning I was told to get my helmet and report to the aviation physiologist at the equipment lab. The doctor, who was well liked, was tall, extremely thin (we told him he would have to tread water in a test tube), and determined to make flying as safe and comfortable as possible. At the time, he was trying to find ways to make fighter pilots more comfortable on long flights, particularly overwater flights. When one had to cross an appreciable body of water, the seat cushion was replaced with a packed life raft. Since you can't move around much in a fighter cockpit, sitting on a life raft for six or eight hours becomes quite uncomfortable. (It's not so much the raft—it's the propeller on the outboard motor that really hurts.)

The lab staff had devised a hammock seat that would suspend the pilot a few inches above his parachute and conform to his body contours, providing comfortable support. The rig consisted of a piece of heavy canvas about four feet long by 18 inches wide that was attached to the inside of the parachute harness with four grommets: two at the pilot's shoulders and two at the front of the parachute pack under the pilot's knees. There was sufficient slack in the canvas to provide a hammock-like seat with a hole in the center of the lower end for the parachute leg straps to pass through.

For the flight test, the seat in a P-51H Mustang had been replaced by a metal framework of the same size. The seat belt and shoulder harness were attached to the frame, along with four L-shaped pins that mated with the grommets on the canvas. To get into the cockpit I had to brace my feet on the rudder pedals and my back against the armor-plate rear cockpit wall until the doctor's henchman slipped the grommets over the pins and the hammock could support my weight. The lab staff had already completed hours of ground tests and knew the seat met the comfort requirements. My job was to test it in combat maneuvers, including positive and negative G loads.

As directed, I flew straight and level for a while. The seat was indeed comfortable. I had no problems with turns, dives, rolls, and high G loads, but when I pushed over at the top of a zoom climb the negative Gs lifted the left shoulder grommet off its hook. When I leveled out, my parachute hit the floor, dropping me below the cockpit rim, where I listed to port with my knees up.



DAVID CLARK

This was a real predicament. It would be impossible to land in this ridiculous position, so I frantically tried to get the grommet back on the hook. But I couldn't get my feet under me to lift myself up, and I could barely reach the wayward grommet. My best chance would be to do a series of pushovers and hope to slip the grommet over the pin in the few seconds of negative G. After several futile attempts I succeeded only in lifting the right shoulder grommet off *its* hook. Now I was sitting square on the cockpit floor with my knees up.

I couldn't see out of the cockpit except for straight up, which is no help in landing. Hoping that I wouldn't have a midair collision with another pilot reduced to sitting on his cockpit floor, I settled down and tried to figure a way out of this fix. I ruled out having another pilot talk me through a landing, making an upside-down approach and rolling out just before touchdown (that got very brief consideration), and bailing out, assuming that I could from that position.

I hooked my feet behind the rudder pedals and drew them to the full aft position, then braced my feet against them and pushed forward on the stick. When there was enough negative G to lift me off the floor I was able to brace my back against the armor plate.

I somehow managed to hold this position until I landed and taxied off the runway. By now my legs were shaking so badly under the strain that all I could do was shut off the engine, open the canopy, and sit on the floor. When the doctor came to help me out of the cockpit, I explained what had happened. He came up with the idea of putting catches on the hooks so the grommets could not come off inadvertently, but that would make it virtually impossible to bail out. It was back to the drawing board for him and back to the squadron for me. I never heard of the hammock seat again; I can only hope the idea was abandoned.

When I got back to Operations, looking somewhat the worse for wear, someone asked me what had happened. I told him I had just become the first person to land a P-51 while standing up.

—Donald S. Lopez

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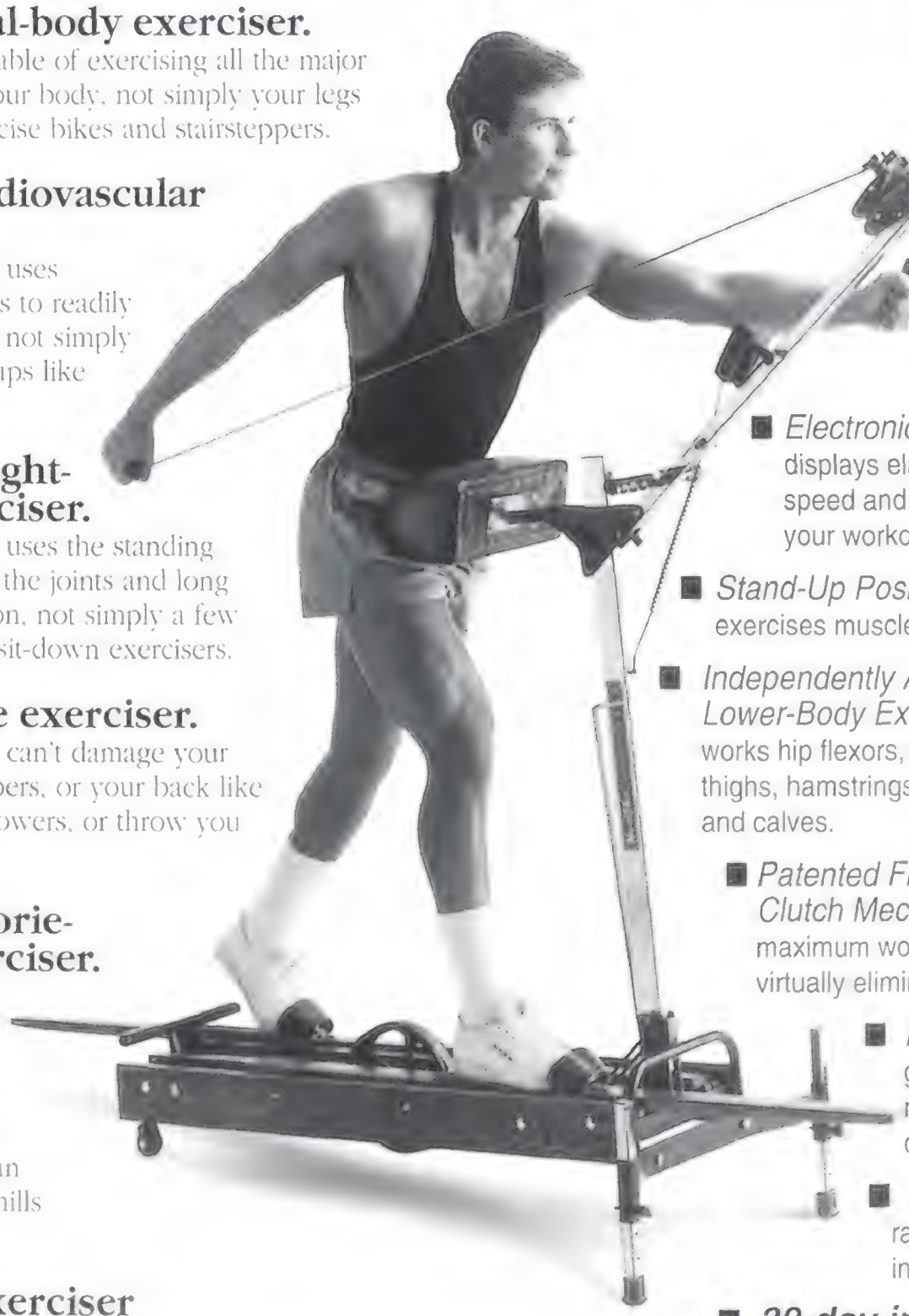

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At the Threshold of Space

Even though NASA had high hopes for the rocket-powered X-15, it still got more than it had bargained for.

by Jeffrey L. Ethell

Even on the ground an X-15 was impressive. A 50-foot black needle with stubby wings and a wedge-shaped vertical tail, each rocket-propelled craft looked like the ultimate hot rod. In the late 1950s, North American Aviation built three X-15s, constructing them from incredibly tough, heat-resistant Inconel-X alloy, which was also used to make jet engine turbine blades. Designed to fly into the hypersonic range above Mach 5, the X-15s also possessed the brute force to leave Earth's atmosphere. With them, the United States had made its first investment in manned spaceflight without really intending to.

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Perhaps the most successful of the X-planes, the rocket-propelled X-15 reached the fringes of space. On later flights, equipped with an ablative coating and external fuel tanks (above), the X-15 flew almost seven times the speed of sound.

Adapted from *Smithsonian Frontiers of Flight* by Jeffrey L. Ethell,
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Before landing, the X-15's pilot jettisoned a portion of the ventral fin and deployed landing skids. Its flight over, the craft was poked and prodded like a laboratory animal (above).

NASM

Robert J. Woods, the designer of the X-1, had submitted the first formal proposal for a hypersonic research vehicle to the National Advisory Committee for Aeronautics in 1951. By 1954, John Becker, head of an informal hypersonic research group at the NACA's Langley, Virginia laboratory, had submitted a design to headquarters for an aircraft with a cruciform tail, an Inconel-X chrome-nickel skin that could withstand high temperatures, and a wedge-shaped vertical fin for increased stability at high Mach numbers. The aircraft was later defined as capable of flying 6,600 feet per second or more than 4,100 mph, of tolerating temperatures as high as 1,200 degrees Fahrenheit, and of climbing to 250,000 feet. In September 1955 North American won the contract to build the aircraft.

Three years later the first two X-15s were trucked to Edwards Air Force Base in California and fitted with two XLR-11 rocket engines each, the same engine that had blasted the first X-1 past the speed of sound. The third X-15 remained behind to await completion of the more powerful XLR-99 engine, which had proved to be the program's most difficult technical challenge.

Although the X-15s had nosewheels, their main landing gear consisted of two skids that were so short the lower half of the ventral vertical fin had to be jettisoned before landing. Still, better landing gear was unnecessary because the airplane was not intended to take off under its own power. Instead, a B-52 bomber was modified to carry the aircraft aloft for airborne release. The first few tests were captive flights, with the airplane never even leaving the bomber. Even in these tests, the X-15's auxiliary power units, which provided electricity for the instruments and the hydraulics during unpowered portions of a flight, would burn out, filling the cockpit with smoke. North American test pilot Scott Crossfield announced "Smoke in the cockpit" over his microphone almost every flight. The APUs became such a headache that during the final captive flight, when Crossfield happened to remark "Holy smoke!" about something else, North American engineer Charles Feltz jumped up and yelled, "Wha'd he say? Wha'd he say?"

By June 8, 1958, everything was ready for an unpowered free-fall flight. From the moment the X-15 was dropped at 38,000 feet, Crossfield had just under four minutes to learn all he could about flying and landing the aircraft. As he approached the dry lake bed at Edwards for landing, he jettisoned the ventral fin's lower half. The X-15 began to por-

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North American Aviation test pilot Scott Crossfield (above) flew the X-15's initial flights. Later pilots included future moonwalker Neil Armstrong (left) and the Air Force's Joe Engle (opposite), who thought the rocket plane was "a good pilot's machine."

poise, pitching up and down in movements that were out of phase with Crossfield's control inputs.

"Now the nose was rising and falling like the bow of a skiff in a heavy sea," Crossfield recalled in his book *Always Another Dawn*. "Although I was putting in maximum control I could not subdue the motions. The X-15 was porpoising wildly, sinking toward the desert at 200 miles an hour. I would have to land at the bottom of an oscillation, timed perfectly; otherwise, I knew, I would break the bird."

Crossfield had the overwhelmingly uncomfortable feeling that somehow, "we had pulled a tremendous goof. The X-15 in spite of all our sweat and study, our attempt at perfection, had become completely unstable." In a nearly miraculous moment, however, as the aircraft was about to hit the ground, the nose pitched up, the skids slammed into the lake bed, the nose gear hit, and the aircraft slid safely to halt.

Much to everyone's relief, the porpoising problem was easily fixed by modifying the control system to keep the pilot's inputs from getting out of phase with the boosts provided by the hydraulics system. From that point on the X-15 displayed excellent handling characteristics.

Crossfield made the first powered X-15 flight on September 17, 1959, in airframe #2. This, as historian Richard P. Hallion wrote in *Test Pilots*, would be "a simple check flight to Mach 2.11—pretty tame stuff by 1959." And indeed, the flight was routine almost to the end, when a fire broke out in the engine bay and caused substantial damage before it was extinguished after landing. The second flight went well. The third powered flight, however, was anything but routine.

Just after launch on November 5, the engine's fuel sequencing system failed and exploded. Having lost power and still heavy with a full fuel load, the X-15 fell like a stone, leaving Crossfield unable to jettison most of the fuel. He made an emergency touchdown on Rosamond Dry Lake; as the nose gear slammed down, the heavy load broke the X-15's fuselage.

When the rescue pilot arrived, he noticed the canopy wasn't open and assumed Crossfield's back had been broken. After grabbing a rescue backboard to immobilize what he thought would be a severely injured X-15 pilot, "the rescuer wanted to throw the canopy wide open to get the backboard in," remembers Crossfield. "I didn't want it open because if it goes past the T-pin, it arms the ejection seat. I can't say anything because I am sealed in my pressure suit so I'm hanging on to the canopy for dear life while this big football player is trying to lift it. Here I am strapped in and pulling the canopy down, fighting until the other guy decides I didn't have a broken back after all." Crossfield finally got his face plate off and told the confused Samaritan not to pull the canopy off. "I had visions of the ejection seat cremating my rescuer and finding myself at 400 feet with no airspeed and the parachute in my lap."

It took three months to repair #2. In the meantime, the NACA's successor, the National Aeronautics and Space Administration, accepted X-15 #1, which was flown by Joe Walker and Bob White in March and April of 1960. And then, finally, the third X-15 was ready for static engine test runs with the XLR-99. On the last ground run, Crossfield was in the cockpit when a pressure regulator stuck; as he later recalled, "the world came unglued" and the propulsion system blew the aircraft in two. After experiencing a 50-G acceleration, Crossfield climbed out of the X-15's battered front section with a sore neck. He later developed a series of eye problems that required him to wear dark glasses at times, but he didn't tell anyone, fearing that he would lose his place in the program.

In November 1960, Crossfield made the first XLR-99-powered flight in the #2 airframe. With the throttle almost at idle, he hit Mach 2.97, demonstrating to everyone that the machine was ready

for its prime purpose: aerodynamic research at Mach 6. From that point on the X-15 program went like gangbusters. A number of pilots were assigned to the program, including the Air Force's Joe Engle and Mike Adams. Engle felt so at home during his first X-15 flight that he rolled it, just as Chuck Yeager had rolled the X-1 on his first flight. "The X-15 was a good pilot's machine," Engle says. "I was very comfortable on that first flight so I rolled it. Now, rolling an experimental aircraft is not really the thing you want to go out and do all the time, but the F-104 had been such a good simulator for the X-15 that everything was familiar. I really loved it as an airplane, regardless of its incredible performance potential, and I would have flown it as much as they would have allowed me to. I love flying all kinds of airplanes, from the World War II P-40 to the space shuttle, and the X-15 was right up at the top for sheer fun. I'd fly it again if they'd let me."

Within a year Bob White had hit Mach 6.04—an incredible 4,093 mph—at 101,600 feet, driving the aircraft's skin temperature beyond its design limits to 1,300 degrees. By August 1963 Joe Walker had taken the X-15 to 354,200 feet—more than 100,000 feet above the X-15's planned maximum altitude and a world altitude record for winged aircraft that still stands. Since space is considered to begin at an altitude of 50 miles, the five military X-15 pilots who flew this high or higher later were awarded astronaut's wings.

For the first time a winged rocket was leaving the atmosphere, shifting from conventional flight to spaceflight, then returning to Earth. Although the aircraft had been built to conduct hypersonic research within Earth's atmosphere, it was helping to pave the way toward manned spaceflight. John Becker, head of the NACA panel that had initiated the X-15 design, remarks, "If you take a broad look at all of the contributions of the X-15 program and consider relative values based on the actual use that has been made of the results, it becomes quite clear that the space-oriented results have been of greater value and importance than the hypersonic aeronautics contributions. This is the reverse of what was expected in the beginning."

Although the first manned space missions of 1961 and 1962 overshadowed the X-15's accomplishments, those who had toiled on the aircraft knew the importance of the rocket plane's role. By 1964, two-thirds of all data gleaned from the X-15 was being applied to other programs, including the Apollo-Saturn launch vehicle that was designed to place humans on the moon.

Flying an airplane—even a rocket-propelled one—into the almost-nonexistent atmosphere at the edge of space offered new challenges to pilots. "During reentry, side-slip was very critical until the wing surfaces again began to generate lift and became effective," Engle recalls. "Aircraft #1 and #2 had a separate side stick on the left side of the cockpit for reaction controls used to control attitude in space, another side stick controller on the right for the aerodynamic surfaces at high speeds, as well as the normal stick and rudder for slower flying in the atmosphere. It really required some coordination using both hands and all three sticks at certain points in the flight. Aircraft #3 had all three control systems blended together, which reduced pilot workload significantly. This was the direct pre-

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EDWARDS AFB HISTORY OFFICE

Pilot Pete Knight (right) flew the X-15 to Mach 6.7, which remains an unofficial speed record. When Bob White (below) took the X-15 to 314,750 feet on July 17, 1962, he became the first X-15 pilot to get astronaut's wings.

After the X-15 was released from the B-52, its rockets took over. Milt Thompson, for one, thought the acceleration was "very uncomfortable."

decessor to the space shuttle flight control system."

NASA assigned several pilots to the program, including Neil Armstrong, who would later become the first person to set foot on the moon, and Milt Thompson. Both found the X-15 to be just as challenging as Engle, Crossfield, and the other pilots had. The thrust from the accelerating X-15 was stronger than that of any airplane Thompson had flown. "The longitudinal acceleration approached 2 Gs and built up to 4 Gs, and though I throttled back I was pressed back into my seat," recalled Thompson, who died in August. "The instrument panel looked strange. I was behind the airplane all the way up to burnout. It was the first airplane I'd flown that I was happy to shut the engine off. The acceleration was very uncomfortable."

By early 1967, NASA had modified airframe #1, which had been badly damaged in a crash, and started to prepare the aircraft for initial high-Mach trials. It received an ablative coating that consisted of a resin base, a catalyst, and glass-bead powder; if this protection worked, it would prevent the aircraft from reaching temperatures above 2,000 degrees as it rushed through the atmosphere. The coating would then burn off as a sticky residue, which unfortunately would end up covering the windshield. To get around the problem, North American added an "eyelid" on the left windshield that could be mechanically controlled by the pilot. After launch, the pilot would use the right windshield until it became covered, which usually occurred at about Mach 3. From that point up through speeds of about Mach 6 and then back down to Mach 3, the pilot was totally blind until he opened the eyelid on the left.

The Air Force had reassigned William J. "Pete" Knight, who had been a pilot with the now-defunct X-20 Dyna-Soar spaceplane program, to the Mach 8 X-15 effort. When he first saw the X-15A-2, with its pink ablative coating, he was astounded. "I said I wouldn't fly a pink airplane. They painted over it with white paint."

On August 21, 1967, Knight took the craft up for its first flight with the new coating and pushed it up to Mach 4.94 with no problems. Now the pilot and plane would go for "all the marbles." On October 3, a B-52 took Knight and

EDWARDS AFB HISTORY OFFICE (2)

the X-15, fitted with a model scramjet for aerodynamic testing, aloft for the flight. Knight separated from the B-52 over Nevada, lit his engine, and, as he climbed, pointed the sleek javelin in the direction of Edwards. When the large external tanks had spent all their fuel, he switched them off, leveled off at

Eight X-15 pilots flew high enough to earn astronaut's wings, although three of them were civilians and not eligible. (Pictured, left to right are X-15 pilots Joe Engle, Bob Rushworth, Jack McKay, Pete Knight, Milt Thompson, and Bill Dana.)

X-15 designers did consider launching an orbital version on a rocket, but the only first stage the rocket plane ever got was a B-52.

102,000 feet, and kept the throttle up. When the engine quit, he was traveling at Mach 6.7, a blistering 4,520 mph.

Normally, after Knight landed, the recovery crew would gather around the front of the aircraft to offer congratulations. "This time they all went to the back of the aircraft," he recalls. "Something must be wrong. I got out and looked. The scramjet had burned off the lower ventral, which had severe damage due to high temperatures. It was like a blowtorch had melted through into the engine bay and cut the stainless steel lines."

The temperatures, more than 3,000 degrees, had not only burned off the scramjet but also opened up a seven-by three-inch hole in the leading edge of the ventral fin, allowing the searing heat to enter and to weaken the internal structure. The X-15 had come within a few seconds of disintegrating. Plans for flights to Mach 7 were abandoned and, although the aircraft was rebuilt, it never flew again. Pete Knight and the X-15A-2 still hold the world's speed record for a winged flying machine.

"When I was assigned to the X-15 program," recalls Knight, "the idea was to expand the envelope of the airplane out to Mach 8 and develop the flight environment for a scramjet engine. The only limit to maximum speed would be the amount of fuel carried. We had no idea what was going to happen. I was fortunate to go as fast as I did and live. I thought I wasn't going to make it through that last flight. That I did go that fast is an accomplishment which should be attributed to the people in the X-15 program who made it happen."

Following the crash of X-15 #3 on November 17, 1967, which killed pilot Mike Adams, only X-15 #1 was still airworthy, and the sun set on one of the most valuable and daring flight research programs in history. On October 24, 1968, NASA pilot Bill Dana made the 199th and last flight of an X-15. Though technicians tried desperately to pull off a 200th, it was not to be. The next year X-15 #1 was shipped to the National Air and Space Museum.

X-15 #1 is now displayed in the National Air and Space Museum's Milestones of Flight Gallery.

Rated X

The X-plane program dates back to 1944, when high-performance World War II fighters like the Lockheed P-38 Lightning and the Republic P-47 Thunderbolt began to experience a phenomenon called compressibility. As the aircraft approached transonic speeds (starting around Mach .7), air molecules in front of the wings and fuselage became compressed and formed a shock wave that caused buffeting, instability, and structural overload. To investigate this and other problems associated with high-altitude, high-speed flight, the National Advisory Committee for Aeronautics, the U.S. Army Air Forces, and the Navy ordered radically designed rocket- and turbojet-powered aircraft that were loaded with instruments. The craft were rated "X" for "experimental." (Unlike commercial and military aircraft that carried an X designation during development, these X-planes were pure research craft, not prototypes for potential production.)

The first aircraft in the series were transonic and supersonic research craft that flew during the X-plane's golden age, the late 1940s and early 1950s. Once high-speed flight was conquered, the program diversified. Unmanned missiles made up one block of X-planes, as did vertical-takeoff-and-landing aircraft and lifting bodies, precursors of craft like the space shuttle and the proposed National Aerospace Plane. Along with successes like the X-1 and the X-15, the program had its oddballs: the X-6 was a B-36 converted into a test bed for nuclear-powered propulsion, the X-25 was an autogiro briefly considered for saving ejected pilots and crew, and the X-28 was a single-place seaplane tested as an aeromarine police cruiser.

The lifting bodies and their explorations of a glide-to-landing return from orbit constituted the last big block of X-plane research. Once the space shuttle design was finalized, the X-plane program idled for 13 years until the forward-swept-wing X-29 took flight in 1984. (For a detailed listing of the X-planes, see the graphic supplement included with this issue.)

—Patricia Trenner

Still, the breakthroughs achieved by the X-15 program were pivotal in proving not only that a spaceworthy winged vehicle could work, but that it could be flown into and out of Earth's atmosphere. Without the practical data generated by the X-15 and its talented 12 pilots, the first space shuttle flight would have been delayed much longer. After it had been all but forgotten, astronaut John Young, commander on the first shuttle mission, paid homage to the black bullet. "The lift-to-drag ratio of the space shuttle is almost identical to that of the X-15. They were very similar programs and there was a great deal of feedback from the X-15 to the shuttle. It really paid off."

CAROLINE SHIFEN

Reality Check

When NASA began preparing for the Hubble repair mission, it came face to face with an important question: How on Earth can an astronaut prepare for work in space?

by William Triplett

The difference between the simulation of space and the reality of it first became apparent to Pierre Thuot when he had to move from *Endeavour*'s forward bulkhead to the rear bulkhead—a distance of about 60 feet. "In space you walk on your hands...and you have to apply force to stop yourself whenever a movement takes you off line," explains Thuot, a crew member on shuttle mission 49 in May 1992. "It's a lot like trying to balance when you walk on your hands on earth. You've got to really hustle to keep your body from going over." What the Navy commander soon discovered was that controlling his body while moving in zero gravity was about as easy as keeping a car with loose steering between the white lines on the interstate. "It was like—whoa, this is a *lot* different than in training!"

Things got worse. Some 35 feet from the *Endeavour* was Intelsat VI, a 17-foot-long cylindrical communications satellite that had been stranded in a useless low orbit. Thuot's job was to capture the 4.5-ton satellite so that it could be properly redeployed. With his boots securely wedged in a foot restraint at the end of the shuttle's robot arm, Thuot hoped to lock on to the satellite's outer rim with a 15-foot capture bar. But his attempts to secure Intelsat VI only sent it skittering out of range.

Back on earth a growing audience got caught up in the drama as Thuot tried again on the following day to secure Intelsat VI, again without success. On a third attempt he and two other crew members were finally able to grab the satellite and save mission 49. But for some at Johnson Space Center in Houston it was a qualified success. "*This is the kind of stuff you go through* before *you fly*," Richard K. Fullerton, a flight operations engineer, recalls thinking as he sat at his console. Later, a significant number of the woes that plagued the Intelsat VI capture would be identified as systemic problems in NASA's approach to astronaut training.

"When I reviewed the tapes from the first capture attempt," says a Johnson mission manager who asked not to be identified, "it became obvious we had drawn some conclusions based on ground simulators that were optimistic at best." His perception was reinforced by subsequent spacewalks on that mis-

The enormous challenges of working in space were dramatized by the difficulties Pierre Thuot encountered as he attempted to lock on to Intelsat VI with a capture bar while perched on the shuttle's robot arm.

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sion. "I knew [then] we would have to revisit our mission preparation and training methodology."

The good news: following the mission, internal reviews showed that the training problems had been confined to what NASA calls extravehicular activity—when astronauts work outside a spacecraft. But that was also the bad news. Since 1965, when Gemini 4's Ed White became the first American to walk in space, EVA has evolved considerably. Originally thought of mostly as something to do in emergencies—payload doors won't close? Send an

Some 200 miles above the Bahama Banks, Dale Gardner (below) approaches Westar VI; protruding on the right is the shuttle's robot arm. The encounter was a replay of crewmate Joseph Allen's rescue of Palapa B-2 the day before. Both satellites were returned to earth for repair in November 1984.

astronaut out to fix 'em—EVA is expected to become "the cornerstone" of the manned space program, according to Ron Farris, head of the EVA Section at Johnson. In fact, construction of the space station will depend heavily on EVA. And for maintenance and repair, it's estimated that the most recent station design will require about a dozen spacewalks per year.

"EVA was initially a kind of afterthought for shuttle missions," says Farris. "If we couldn't afford the weight of some mechanical device, we'd make whatever task it involved an EVA thing. People just began to assume this efficiency of EVA." To some extent that was a fair assumption, as astronauts generally completed their EVA tasks within the time allotted. But the Intelsat VI rescue mission was different. In addition to the problems with the communications satellite, crew members Kathryn Thornton and Thomas Akers encountered unexpected difficulties during a free-floating EVA exercise that was intended to test methods of space station construction. "All I know is the ground kept calling up and saying, 'Don't do this task, forget that one, delete, delete, delete...,' " remembers Thornton. "Each [call] was more and more demoralizing. It was clear we were hopelessly behind."

But long before space station construction gets under way, EVA will face a critical test: the mission to service the Hubble Space Telescope. The 11-day mission (currently scheduled for early December) will include five spacewalks lasting six hours each. In addition to some heavy maintenance work on the 42-foot telescope, which has now been in orbit more than three years, two pairs of astronauts are expected to perform a variety of repairs. Their primary objectives will be replacing up to three gyroscopes, two solar arrays, and two magnetometers, as well as installing an upgraded wide-field/planetary camera and the Corrective Optics Space Telescope Axial Replacement, which will fix the telescope's blurred vision.

Unlike Intelsat VI, the Hubble was designed to be serviced by a shuttle crew, and it includes grapple fixtures and handholds to assist in the capture and repair. But the stakes are still high. Given the lingering public relations de-

James van Hoften (top, center) and George "Pinky" Nelson made the first repair of an orbiting satellite in April 1984. An initial attempt to capture Solar Max failed, but the astronauts completed the mission the next day. Ron Farris (above), head of the EVA Section at Johnson Space Center, is developing a database to build knowledge on how astronauts should work outside spacecraft.

bacle resulting from the Hubble's flawed lens, as well as the continuing debate in Congress over the space station, any recurrence of mission 49's problems would have grave consequences. It's widely recognized that a failure on the Hubble repair mission would certainly raise a warning flag in Congress about station funding. Such a mishap wouldn't be the sole criterion for deciding the future of the space station, says a space policy expert on Capitol Hill, "but it

Bruce McCandless (left) made the first untethered EVA when he flew a manned maneuvering unit on mission 41-B in February 1984. The nitrogen-propelled, hand-controlled device took him 320 feet from the orbiter. In 1983, Story Musgrave (below), payload commander for the upcoming Hubble mission, made the first spacewalk from a shuttle.

would be one of the major ones."

NASA is acutely aware of how much is riding on a satisfactory outcome of the Hubble mission. "We've got to be successful with Hubble or we may not get the chance to prove we can be successful for space station," says the mission manager. To make sure everything goes accordingly, a half-dozen panels have been established to review plans for the Hubble mission. The outcome would seem to depend on how quickly the agency can rework its EVA training in the 18 months between the Intelsat VI and Hubble missions. Already one review panel has criticized EVA planning and training.

"There's an awful lot of art to EVA," says Story Musgrave. "It has all the elements of dance and ballet and gymnastics, and maybe because of that—the human element—it's not like the stuff of engineering." Musgrave, one of the astronaut corps' elder statesmen, belonged to a NASA group that reviewed mission 49. As the payload commander of the Hubble mission, he and Jeffrey Hoffman make up one of the two astronaut teams that will perform the EVAs. Kathryn Thornton and Thomas Akers are the other team.

Last July the EVA astronauts for the Hubble mission visited the National Air and Space Museum to check equipment fits and familiarize themselves with the Museum's space telescope mockup. Hoisted by a cherry picker normally used to clean artifacts, the astronauts got the best vantage point they will have of the Hubble until they are actually on the shuttle's robot arm. It was just the latest in a round of EVA training that started when the astronauts were still new recruits.

EVA training is centered on familiarizing astronauts with working in a spacesuit in the zero-G conditions of space. The zero-G achieved by flying parabolas in a KC-135, a.k.a. the "Vomit Comet," only lasts 30 to 40 seconds, and NASA relies on vacuum chambers and a variety of other simulators to recreate the weightlessness of space. The principal training ground is a 25-foot-deep water tank, which offers the best prolonged simulation of weightlessness that NASA can devise (see "Charlie and the Aquanauts," June/July 1993). Using water as a training ground for space

William Fisher installs a protective cover on the engine nozzle of Syncom IV-3 during an August 1985 mission. Although not designed for in-orbit servicing or retrieval, the satellite was successfully captured and reactivated.

has drawbacks, however, which were made blatantly obvious during the Intelsat VI mission. Because water is viscous, it offers resistance—a phenomenon that acts as a stabilizing force. "You end up using the stability of the water whether you intend to or not," says Thornton, and that can undermine the EVA experience in space.

The Precision Air-Bearing Floor has demonstrated in other ways the enormous challenges of simulating space. Essentially a huge frictionless surface, the smooth, finely polished floor is used to practice moving massive objects. During training for the Intelsat VI mission, however, the simulator erroneously provided approximately five times more resistance to force than what the satellite in space would offer. The result was that the triggering of the locks on the capture bar was misadjusted by a factor of five. "We knew the risk [of inaccurate simulation] was there, but we underestimated it," concedes Randy Stone, assistant director for space shuttle mission operations and flight operations director for mission 49.

Moreover, Thuot trained on a shuttle arm simulator that for safety had been securely anchored; the result was more stability and resistance than space would offer and, hence, unrealistic training conditions. "The crux of why [the Intelsat VI rescue] didn't go as planned is that Pierre was able to capture the mockup every time," says Musgrave. "And if you're capturing every time, that does not get your attention."

Still, some EVA problems can be blamed on a "can do, no sweat" image that pervades NASA, as well as the fact that experience often takes a back seat. "There's a tendency among crews to think they can do something better or faster than a previous crew," admits Farris, "and sometimes as a mission planner you have to use your judgment. EVA is a very subjective thing. It's a function of suit fit, upper-body strength, dexterity, and endurance. And some people can do things better than others. So your judgment sometimes says, 'Okay, well, maybe they *can* do it better or faster.' " Farris says that the mission planners had originally allotted more time for the construction tasks. But as the crews became more proficient in the water tank, "they felt our times were not using the [overall] on-orbit time efficiently. So we said, 'Okay, we'll shorten up times and add some more tasks.' "

Richard Fullerton says that mission managers had suspected that the plans for rescuing Intelsat might prove unrealistic, but "the whole point of [mission] 49, especially the [construction task] side, was to push the envelope, to see what you can and can't do in terms of free-floating." In other words, it was an experiment, the intrinsic value of which, says Farris, was that "we learned something. We learned that what we'd planned wasn't very efficient. And that's the reason you do these things."

This may have the unmistakable ring of making the best of a taxpayer-funded goof—we learned that what we'd unreasonably planned was unreasonably planned. However, Kathryn Thornton points out that if "we had planned to do less and were successful, we wouldn't have learned nearly what we learned." NASA would have continued to put too much faith in the efficiency of EVA, "and we would have been in a world of hurt on the first space station mission."

In that respect perhaps it *was* an experiment—one whose results and implications turned out to be more important than anyone had anticipated.

Mission 49 was, in the words of Ron Farris, "an efficiency wake-up call," and its impact on astronaut training has been dramatic. One of the biggest changes has been more EVA training aboard the shuttle, which was prompted by a strongly worded memo the astronaut office issued three months after the Intelsat VI rescue mission. At the time, only 10 of the 92 astronauts on flight status had ever walked in space, yet no EVAs had been planned for the five shuttle flights scheduled before the Hubble mission.

"EVA is one of those things you just can't train for on the ground," explains Pierre Thuot. "It's like taking someone who's only trained on a Cessna 172 simulator and telling them to go fly an F-14. You can tell somebody that just [moving] along the line is probably the hardest thing you have to learn in space, and you can tell them that they have to slow down in the water tank because you won't be able to control yourself going that fast in space. But you won't know what it's like until you do it."

More EVAs have subsequently been scheduled, starting last January with mission 54, which included the first EVA for EVA's sake. Mission 57 in June included an EVA exercise in which two astronauts practiced carrying each other around the payload bay to simulate handling massive objects. Mission 51 is scheduled to evaluate tools that will be used on the Hubble mission.

The astronauts and the EVA Section also got permission to develop a formal EVA database. The aim is to thoroughly

Randy Stone (above, seated), assistant director for space shuttle mission operations, was flight operations director for the Intelsat rescue mission. He's confident that the Hubble mission will go much better. Following the initial failure to capture Intelsat VI, Story Musgrave (below) practiced on Johnson's mass simulator to gather information for the next try.

debrief spacewalkers, sometimes even while still in orbit, in order to build EVA knowledge. Musgrave believes this knowledge is long overdue. What was missing during training for the Intelsat mission, he says, was "someone with a bird's-eye view on the historical process, someone looking from a distant standpoint saying, 'Okay, we've captured every time, but have the dynamicists looked at this simulator for accuracy?' "

Ron Farris is charged with developing and maintaining the database, and one of the first things he did was to put the mission 49 crew back into the water tank to compare the time it took to execute the exact same tasks in water and the time it actually took in space. The results were intriguing. The first few attempts in the tank most accurately matched the elapsed time in space. "The reason is that early on you're still developing procedures and everybody's moving slowly because they're not sure what they're doing," says Fullerton. "Later on you get faster because you know more of what you're doing." The upshot: Johnson Space Center now looks at the times of the first runs in the water tank as more representative of what actual times will be in space.

The crew for the Hubble mission is also the first shuttle crew to train with virtual reality, which provides an opportunity for the astronauts to choreograph their movements using computers that offer three-dimensional visuals and gloves with tactile simulation. NASA has been experimenting with this technology for several years, and it's currently being evaluated as a training aid.

In addition to new training procedures, NASA is developing a new philosophy on EVA. "We've got to maintain a skepticism around here," says Musgrave. "NASA needs to tell the public that we want to succeed with Hubble and we're giving it our best shot,

In a dramatic third attempt, Richard Hieb, Thomas Akers, and Pierre Thuot (left to right) finally managed to capture Intelsat VI. Their eight-hour, 29-minute spacewalk was the longest in history and the first three-person EVA.

Kathryn Thornton (above) rehearses in a vacuum chamber for mission 49 and space station construction exercises. She and Thomas Akers make up one of two astronaut teams assigned to service the Hubble space telescope. Akers (below) works with a training version of the wide-field/planetary camera in the water tank at Johnson.

but it's a pioneering, exploratory, and experimental effort." When it's pointed out that circumspection isn't often heard around NASA, he cuts in, "You *don't* hear it. That's why I'm telling you."

Musgrave is also trying to make sure that, though astronauts train in water, they don't act like they walk on it. "The divers who work with us in the water tank have a huge experience base that's been totally neglected. After all," he says facetiously, "you're an EVA astronaut—who are they to put their hand in front of your face and try to tell you you're doing something wrong? We have empowered the divers to interject at any time."

What it all adds up to, NASA hopes, is a comprehensive overhaul of EVA training that draws on every available resource. Farris describes it as "a fairly scientific approach to quantifying what your EVA operational envelope really is."

So will NASA's new, improved approach to EVA pass its first test? Randy Stone has no doubt the Hubble mission will work like a charm. "Comparing Intelsat to Hubble is like comparing apples to oranges," he says. "Hubble was designed to be worked on, so [capturing it] will be a zip problem. This is a task we know how to do. There will be fewer unknowns with Hubble, so few that I'd be surprised if we are significantly surprised." The mission manager who requested anonymity seconds this viewpoint, but he acknowledges that confidence is not universal within NASA. "The people here [at Johnson Space Center] who've been working every day on preparing the mission are not nervous," he says. "Hubble was designed for EVA and we've got the right tools and experience." (NASA assigned EVA veterans to the mission.) "But the higher levels of management don't have as much confidence because they haven't been working on it every day like we

have. There's a lot of nervousness up there."

Perhaps there should be. "NASA really gave the impression that Intelsat would be a piece of cake," says the Congressional space policy expert, who adds that this wasn't the first time "NASA ended up looking awkward, saying afterward, 'Well, we were a little off here, a little there....'"

Ask Story Musgrave if he's nervous about the mission and he replies: "I'm just scared. Hubble is an incredibly friendly device to work on, but space is a very corrosive environment in its own way. Things get hurt up there, get stuck, blown around. That will make things a little different for us when we get there." True to form, he emphasizes the kind of caution an astronaut might use when walking in space for the first time. "People need to know the flight plan will not go the way it is. The flight plan is a template, but when we go flying that's not the way it's gonna work. If you ask me are we gonna succeed, I'll say I don't know, ask me when I get home. This is a drama that has to be played out, whose end nobody knows. So stand by."

Into Harm's Way

A team of NASA scientists tackles a deadly threat to air travel by facing it head on.

by Carl A. Posey

To anyone viewing it from the rain-soaked salad of tracts and farmlands around Orlando, Florida, the airplane must seem to be in trouble. Instead of following the austere paths of most low-flying Boeing 737s—aircraft usually seen at this speed and altitude only when landing or leaving—this one weaves ominously around the countryside below the tops of a trio of strobing 1,600-foot television towers. Now and then it drops to within 800 feet of the ground to charge shafts of rain beneath budding thunderstorms like a tricolor bee attacking lavender flowers. Despite its altitude and erratic behavior, however, NASA 515, its pilots—three of them in all—and its flight decks—both of them—are calm. Indeed, the men and women aboard are looking for trouble, provided it can be found in a tolerable form.

The trouble for which they forage on this August afternoon in 1992 is a sometimes-fatal weather condition known as wind shear. Wind shear is a term that refers to any abrupt change in wind speed and direction. In its deadliest form, the microburst, relatively small downdrafts of cold air—less than 2.5 miles in diameter—explode toward the ground from the rising cloud towers. Like inverted mushroom clouds, these invisible cataracts break against the ground and spray out horizontally, producing winds that flow away in all directions (see "The Might of the Microburst," August/September 1986).

The storm looming before NASA's research 737 looks ominous, but the biggest danger the aircraft routinely faced was an invisible one: wind shear.

Microbursts and their shearing winds can be a rough surprise for pilots, especially during takeoff and landing, when the airplane is flying low and slow. The problem is not really the amount of wind, although downdrafts often have muscle. The danger lies in the element of surprise, the sudden swipe by something you can't see.

An airplane flying into one side of a microburst's descending current first encounters a strong wind blowing toward it—a headwind—which causes a sudden increase in airspeed, the speed of air moving past the airplane. Unaware of the danger ahead, a pilot might respond by reducing power. By then, however, the craft will have crossed to the far side of the downdraft, where the wind blows from behind it—a tailwind—causing a sudden *drop* in airspeed. An attempt by the pilot to add power may come too late to push the airplane out of harm's way.

As H.G. Wells pointed out more than a century ago, however, being invisible is not the same as being undetectable. Dogs could smell Wells' invisible man, his moist breath visibly condensed in cold air, he became a ghostly envelope of droplets in the rain, and his invisible feet left footprints in snow. Likewise, microbursts, in the view of the scientists flying aboard NASA 515, can be seen indirectly through different windows in the electromagnetic spectrum. They are proving it in this second and final summer of stalking the invisible man of the atmosphere, and learning how to spoil his ability to surprise.

Dick Yenni, a fit, compact man in his 50s, is pilot in command: copilot Michael Phillips sits to his right. The pair flies a strenuous several hours almost every day, but the most taxing part may be the intervals when they are merely lookouts and the airplane is controlled from its second cockpit. There, Lee Person, a former Marine fighter jock who has spent much of his career gleefully flying blind for NASA, sits in the left seat of a molded fiberglass 737 nose and windscreen that, like a ship in a bottle, has been created inside the fuselage of NASA 515.

Airborne, the research cockpit is eerily out of touch with the real world. Its only visual clue to external reality is a small color monitor fed by a video camera in the nose. On Person's right sits Michael Lewis, the 30-year-old engineer and deputy project manager who links the airplane to the science. Behind him sits Roland Bowles, the soft-spoken Virginian leading the project. They and seven dozen colleagues are in Orlando under the auspices of the Federal Aviation Administration and NASA's Langley Research Center in Hampton, Virginia, where they are based.

The $20 million-plus FAA/NASA Airborne Windshear Sensors Program started in 1986 following a series of dramatic and deadly accidents for which wind shear was to blame. On June 24,

1975, an Eastern Airlines 727 crashed at Kennedy airport in New York, killing 113 of 124 aboard. Another 727, Pan Am's flight 759, crashed at New Orleans on July 9, 1982, killing all 145 passengers and eight people on the ground. And on August 2, 1985, Delta flight 191, a Lockheed L-1011, landed short at Dallas-Fort Worth, killing 134 of the 163 people aboard, along with the occupant of a vehicle on the ground.

In response to these accidents, the FAA launched a multi-pronged attack on wind shear, including the development of a pilot training program and a ground-based system, Terminal Doppler Weather Radar, capable of detecting the phenomenon.

The TDWR produces a very complex, very smart display, but it also has a down side. The radar can look at only one place at a time, and, because it scans a wide area, its wind shear measurements are updated only once a minute. Sometimes the delay between displays exceeds the time for the quick, lethal growth of a microburst over the field; sometimes the radar's vantage point is not the best for any of the runways. Even if the TDWR could see everything all the time and its readout was piped directly into the cockpits, it would still not be enough: of the 800 or so airports in the continental United States han-

Fed by information from two sensors, a computer display inside the airplane makes the danger visible. Red circles indicate the location and intensity of potentially hazardous wind shear; the aircraft's position is at the bottom of the wedge.

dling commercial traffic, only 47 are slated to receive a TDWR.

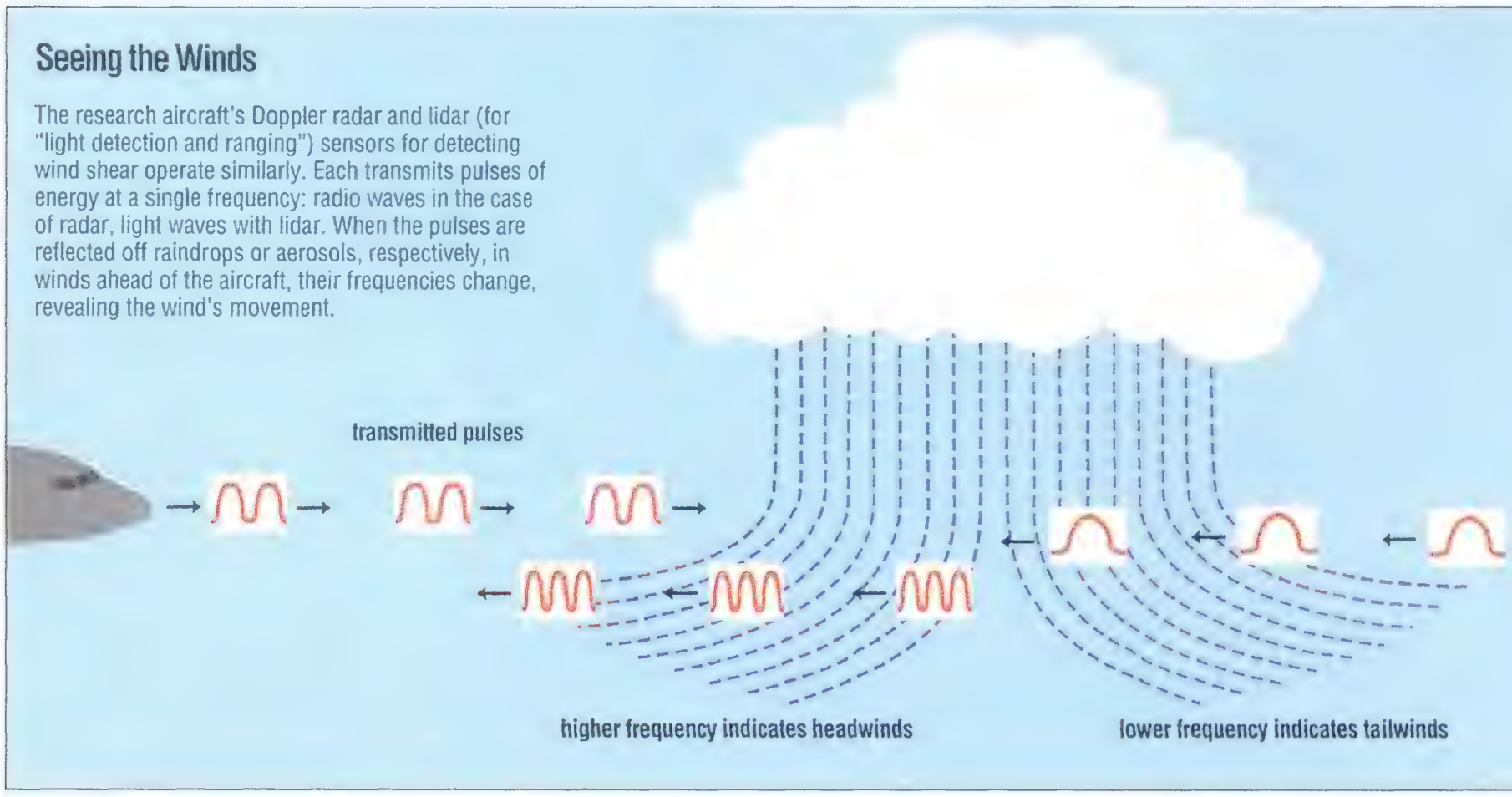
Accordingly, the agency moved to improve the instrumentation on the flight deck as well as on the ground, directing that commercial aircraft carry one of two types of wind shear detection devices: either, by the end of 1993, a "reactive" device that detects wind shear once an airplane has entered it or, by the end of 1995, a device that provides 20 to 40 seconds' advance warning of wind shear. The FAA turned to Langley for the development and testing of these "forward looking" sensors.

As it happened, Langley had just the cockpit for such a project. Years earlier NASA had acquired the prototype of the Boeing 737, which first flew on April 9, 1967. Rescued from the scrap heap by Boeing and NASA, it was rebuilt into a flying laboratory, complete with double cockpits, to test instrumentation then being developed for the supersonic transport. The refurbished 737 moved to Langley in 1974 and, like all government machinery, was given a numbing acronym: TSRV, for Transport Systems Research Vehicle.

What the wind shear team installed in the 737's aft cockpit is on Mike Lewis' side of the instrument panel. A single compact computer display shows a col-

Seeing the Winds

The research aircraft's Doppler radar and lidar (for "light detection and ranging") sensors for detecting wind shear operate similarly. Each transmits pulses of energy at a single frequency: radio waves in the case of radar, light waves with lidar. When the pulses are reflected off raindrops or aerosols, respectively, in winds ahead of the aircraft, their frequencies change, revealing the wind's movement.



Following wind shear alerts, the airplane flew directly into the danger zones. Most of the flying was done blind from a research cockpit in the 737's first class section (left). For wind shear penetrations, control returned to the true cockpit (right).

orful wedge of data representing the area swept by two experimental instruments. One is a modified Doppler weather radar in the nose that measures large, sudden changes in the speed of raindrops in storm systems out to about five miles ahead of the airplane, in effect showing the wind in motion. The other is a lidar—the laser equivalent of radar—that can see similar motion among suspended solids, or aerosols, in the air up to about three miles out (see diagram, opposite). On the display, warm colors indicate performance-degrading conditions, such as increasing tailwinds or downdrafts. Cool colors indicate performance-increasing situations: headwinds and updrafts. Areas of greatest color contrast—adjacent splotches of, say, red and indigo—signify maximum wind shear.

The radar and lidar see the invisible man through different spectral windows. Radar can detect movement within a rain cloud that is opaque to laser light, which water quickly absorbs. But lasers can detect the movement of microscopic particles in clear air, an enormous boon to pilots about to fly into invisible trouble. A third instrument—a passive infrared sensor—peers through a third window. The sensor can be used to infer from thermal data the presence of a downdraft—cold air falls—and at some threshold of threat set off a cockpit warning light. Viewed by this trio of sensors, the invisible man of the atmosphere becomes a naked little guy 20 to 40 seconds ahead of the airplane—at least that is the hope of NASA's wind shear team.

The onboard system takes the display one step further: combining such factors as performance, airspeed, attitude, and altitude with the measured wind shear conditions, the computer comes up with what Langley people call the F-factor, an index of the degree of hazard ahead. In fact, the F-factor indicates what the wind shear will do to the airplane's rate of climb—that is, its ability to climb out of trouble. The threshold of hazard, an F of 0.105, represents a situation in which a pilot can expect to have 1,500 feet per minute sliced off his airplane's rate of climb for about 15 seconds. At that F-factor, the computer display flashes a bold "ALERT." The higher the F-factor, the greater the hazard. "If you give crews the right information," says Roland Bowles, who developed the algorithm for the hazard index, "they do the right thing with it." For NASA 515, the right thing is to fly into the indicated shear zone so that other sensors can probe what the radar, lidar, and infrared indicate they see.

Following weather alerts from a prototype Terminal Doppler Weather Radar at Orlando International Airport, Lee Person and Mike Lewis set up the approaches to areas of suspected wind shear, usually at about 240 mph—much faster than typical approach speeds, for a margin of safety—and some 800 feet above the ground. Up front, Dick Yenni and Mike Phillips watch, sometimes nervously.

For penetrations, control goes back to Yenni in the front cockpit. "If the rain shaft doesn't look right, we won't go into it," he says. "A transparent rain shaft is fine. We don't like to go into solid walls." He grins. "We started out with such constraints that we couldn't get any data." That has changed, but Yenni's caution has not. "We've called it off twice now, to the dismay of some of the researchers. But an hour or two later we're friends again."

It would be remarkable if they were not. The platoon of pilots, scientists, technicians, and ground crew who have come to Orlando this summer following an earlier deployment in Denver share the easy camaraderie of people working hard for a worthy cause. From the day's first flight briefing, which comes at half past noon, through the status updates that often go far into the afternoon, the calm crowd lifts its collective head for announcements, then

returns to a running whist tournament, or airplane talk, or sleep. The lidar people murmur earnestly about their instrument, as do the radar team and the infraredders. One young couple shares a table with a dozen long-stemmed red roses. They were married a year ago, after meeting on the project.

Back then, the spirit in the briefing trailer mustn't have been quite so tranquil. A few weeks in Denver in 1991 netted zero alerts, and another series of flights in Orlando the same year gave them only two—a fallow, depressing deployment. This year has been many times better. They had seven alerts in Denver, and lidar revealed wind shear in clear air. The unstable skies around Orlando have been generous as well. By the time the team's current and final deployment is driven north by the approach of Hurricane Andrew on August 24, they have 13 flights, 35 penetrations of moderate to strong wind shear, and 10 alerts. "We have a mountain of data, magnificent data," Bowles says. "We think we can put the problem behind us. Now it's a matter of letting the marketplace take this technology and make it."

On this August afternoon, Bowles, who says he has been with NASA "forever," seems a happy man. Waiting for the day's flight—one that will garner only two ambiguous alerts—he reminisces about the old days at the agency, when everything they touched seemed fresh and challenging. Solving the wind shear problem, if that is what the Langley team has done here, may be, in its economical way, like finding a way to the moon.

Even in the chancy province of the marketplace, auguries are good. Of the three sensors tested, the Doppler radar showed the most immediate promise, and three manufacturers who worked closely with the FAA and NASA throughout the project are currently in the process of applying for FAA certification for radar sensors they've developed. The first will probably be certified and available for commercial use by this October, the others by next winter or spring. The lidar, developed by Lockheed's Missiles & Space Company, is still considered something of a work in progress, but the company plans to continue development with flight test help from FAA and NASA. Infrared, despite a good deal of flight experience, is not yet that far along, but it is still being pursued.

As for how these devices will alter commercial aviation, no one can say for sure. Perhaps a clue lies in an event that occurred in the first week of the Langley team's Orlando deployment, when thunderstorms stalled commercial aviation from New York to Miami. As NASA 515 trundled out for takeoff, 17 airliners were bunched up awaiting clearance on a parallel runway. A few miles out, the sky was purple, filled with winds no one could see—well, no one but the people on NASA 515. The NASA jet was quickly cleared and took off, looking for trouble. Queried by the restless pilots queued up on the ground, to whom the winds had not yet been revealed, Dick Yenni called back to say that the way was smooth. One day soon, they will not need to ask.

Laser beams point to two of the aircraft's wind shear sensors, the infrared and, below, the lidar. A third, the Doppler radar in the aircraft's nose, has proven the most successful and will soon be used in commercial airliners.

When you were a kid you made yourself a promise.

Maybe this is the year you make

good on it.

So you never hit one out of Yankee Stadium, or headlined at the Garden like you planned. You can still drive a Corvette. And it's even more fun than you imagined it as a kid.

Because today's 'Vettes have 40 years' worth of Chevy engineering breakthroughs: The LT1 engine, one of the world's most advanced small-block production V8s. Dual air bags. The union of Bosch ABS brakes and ASR traction control. And no other Corvette has a cockpit quite as refined as this year's.

So, even though you've wanted a Corvette for as long as you could reach the accelerator, it's probably a good thing you waited until now. Because the 1994 Corvette is the best one yet.

Chevrolet Corvette

How to hit a forest fire
like a ton of bricks.
Make that 30 tons.

Dan McIvor's

Mars Mission

FIGHTING FIRE FROM THE AIR

Part 2

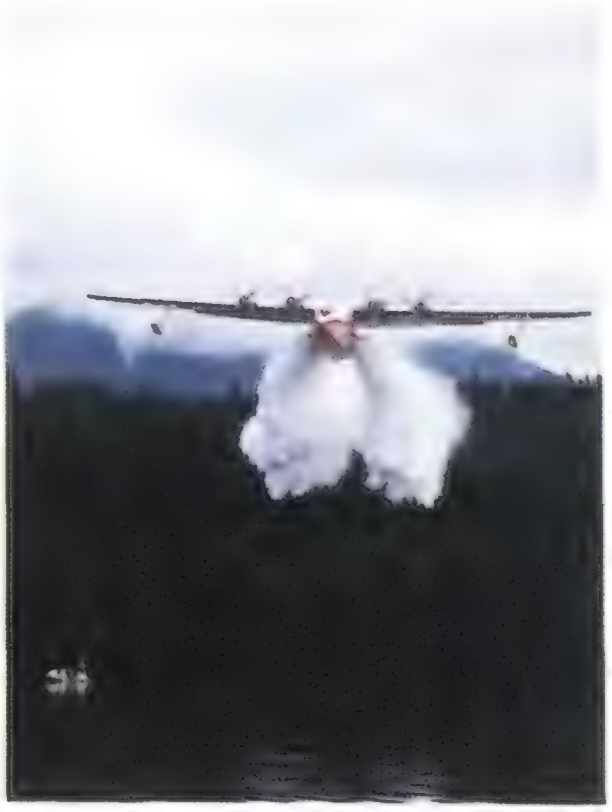
by Ken Gouldthorpe

Photographs by Phil Schofield

The huge craft slips its mooring and glides majestically down the lake like a giant winged oceanliner. Its four engines roar, and the great ship picks up speed—within seconds it is airborne. At first it looks somehow insignificant, flying low over craggy mountains still flecked with snow. Then the great bird tips to port in a steep bank, and as it sweeps back down to the lake like a predatory eagle, gently cleaving the water at 75 mph, its massive size once again becomes apparent.

On board the spacious flight deck,

After serving eight years as a Navy transport, the Philippine Mars *began a second career as a flying tanker for British Columbia's forest industry. During a training flight, the* Philippine *displays its firefighting might.*



A former lieutenant colonel in the Royal Canadian Air Force, Tom Irving (right) runs a tight ship as general manager of Forest Industries Flying Tankers Limited. Without the vision and perseverance of company founder Dan McIvor (opposite), the Mars flying boats would have ended up in a scrapyard.

At 120 feet in length, the double-deck Mars boasts a cavernous interior (opposite). Powering the leviathan are four 2,500-horsepower Wright Cyclone engines, which undergo careful maintenance by FIFT's technicians (below).

two pilots prepare for a second takeoff. "Probes down!" yells one of the pilots. "Probes up!" comes the order 26 seconds later. The huge aircraft, its tanks now carrying 60,000 pounds of water, is airborne again in less than 20 seconds. After gaining altitude, it wheels in a graceful arc back toward the lake. It descends to 100 feet, and at 130 mph it drops its load. Water bursts from its sides, covering about three acres of surface in a dense cloud of spray. The craft touches down for another pickup. On the shore, a crowd has gathered to observe the four-man crew put the ancient tanker through its paces.

Watching the old bird never gets old.

This spectacular sight is unique to a remote neck of the Canadian woods on Vancouver Island, British Columbia, where a tight-knit team of 33 fliers, technicians, specialists, and support per-

sonnel maintain and operate two Martin Mars flying boats now close to a half-century old. That the former U.S. Navy aircraft fly at all is a minor miracle, a testament to the skill of the team's craftsmen and to the vision of an old bush pilot who knew he was destined to fly firefighting equipment that he deems "the best in the world."

Firefighting certainly wasn't what Glenn Martin had in mind for the mighty Mars prototype. In the late 1930s, the Martin company had originally designed the XPB2M-1 as a long-range Navy patrol bomber, but when it joined the Naval Air Transport Service VR-8 unit at Maryland's Patuxent River Naval Air Station in 1943, the Mars was reclassified as a general-purpose transport. It promptly set new cargo-carrying and distance records, won a reputation for ease of operation and maintenance, and earned the lasting respect of its crews.

Delighted with the flying boat's overall performance, the Navy ordered 20 more of the modified craft—designated Type JRM—at a cost of $3.5 million each for the Naval Air Transport Service VR-2 unit based at the Naval Air Station in Alameda, California. But as World War II drew to a close, the order was cut to six. One of these was damaged beyond repair on a test flight in 1945, and another caught fire off Honolulu in 1950. The remainder went on to win fame in aviation circles for their reliability and economy of operation. Known as the Big Four, they logged 87,000 accident-free hours on regular trans-Pacific flights before they were finally beached at Alameda in 1956.

And there, like so many other grand old warbirds, they might have languished until some junk dealer towed them away for scrap. But these flying boats weren't just any old surplus aircraft. They were unique: 120-foot-long, double-deck leviathans with 200-foot wingspans, 13.5-foot beams, and single vertical tails that towered 44 feet above the water line. Their four 2,500-horsepower Curtiss-Wright Cyclone radial engines drove four-blade props just over 15 feet in diameter. And they could carry more than 300 people or 68,195 pounds of cargo in their capacious hulls.

Out of uniform, they were well suited to taking off from and landing on the water in coastal areas, a fact that eventually saved them from extinction. Their second career started in the late 1950s, when Canadian timber giant MacMillan Bloedel Limited, frustrated by its inability to control forest fires, began heeding the offbeat ideas of Dan McIvor, then Mac Blo's senior executive pilot and a pioneer in the use of aircraft as firefighters. McIvor's experiments with primitive water bombing gear had convinced him that in British Columbia's coastal timberlands, waterborne aircraft were the answer. So he set out on a worldwide search for flying boats or amphibians that had the speed, range, payload capacity, and turnaround capability to douse fires quickly.

But the chase was fruitless. The age of the big boats was past, and suitable candidates were either relics or muse-

um pieces. Then, in what McIvor calls a God-given conversation with his old flying acquaintance Bob Morin, who worked for Pacific Western Airlines, he learned that the U.S. Navy was selling off its four Mars flying boats in California. "When?" said McIvor, his heart suddenly pounding. "Tomorrow," said Morin, "and you can have my invitation to bid." In a flurry of phone calls to Alameda, McIvor learned that a further tender would not be accepted. The next day he found out that the entire fleet had been sold to one Hugo Forrester, a scrap metal dealer, for the paltry sum of $26,350. Within days, McIvor and a Mac Blo team were in Alameda to check out the aircraft.

McIvor fell in love. He knew that this just had to be. The airplanes were in prime condition, so he struck a deal with Forrester to buy the fleet for $50,000, then rushed back to British Columbia with his report. To his horror, a cautious Mac Blo turned it down. But by then McIvor was a man with a mission. He hung on to his tentative deal with Forrester, and through shrewd hounding in corporate corridors, backed up by very convincing paperwork, he finally got the go-ahead to purchase the aircraft for a firefighting consortium yet to be formed. In what must rate as one of the biggest aviation bargains of all time, McIvor secured all four flying boats ready for ferry, plus 35 engines and about 90 tons of spare parts, for a total of about $120,000. Included were 44 filing cabinets containing the entire technical history of the Big Four, from service and maintenance records throughout their Navy hitch right down to the original mechanical drawings and a complete set of templates for the hull sections—all of which proved invaluable in the years to come.

In September 1959 McIvor was appointed chief pilot of the newly formed Forest Industries Flying Tankers Limited (FIFT). McIvor and two ex-Navy Mars pilots ferried the *Marianas, Philippine, Hawaii,* and *Caroline Mars* to Patricia Bay off Vancouver Island. Fairey Aviation of Canada modified one of the Mars into a prototype water bomber before eventually converting the remaining three craft. New 7,200-gallon water tanks were fitted into the boats

Like his fellow Mars pilots, Reg Young (above) wishes he could be in the air more often. Flying the Grumman Goose gets him off the ground but lacks the thrill of a practice drop over rugged terrain in the Mars (top). Opposite: chief engineer Roy Copeland (foreground) oversees the rebuilding of a flap.

and existing fuel tanks were modified to carry water. Dumping hatches were either cut into the sides of the hulls or fitted to the bottom of the aircraft like lateral bomb bay doors. Double retractable probes—aluminum scoops—were installed just aft of the step. At Patricia Bay, pilots and technicians took courses under the auspices of grateful Navy Mars specialists who didn't want to see their prized Big Four ignominiously scrapped.

At the FIFT base at Sproat Lake on Vancouver Island, familiarization training rapidly got under way, and shakedown flights soon revealed the true nature of the beasts. Heavy on the controls, the docile giants were slow to respond. Former floatplane pilots, used to skittering about like dragonflies over B.C.'s lakes and coastal waters, had to develop a sense of teamwork and, sometimes reluctantly, learn to rely on the flight engineers, who controlled the engines and propellers and monitored the fuel flow, compressors, hydraulics, electronics, and pump switches through an intimidating instrument console that wouldn't have seemed out of place on the starship *Enterprise.*

The aircraft's massive 60-foot ailerons were not power-assisted, and wheeling the 162,000-pound pterodactyls in tight turns through the craggy valleys of Vancouver Island's timberlands called for Schwarzenegger-style physical effort. Filling the tanks while taxiing at high speed on the water had to be learned on the job. It took trial and error and the shattering of several expensive handmade probes to come up with scoops strong enough to be lowered into the water aft of the step. Properly done, the whole procedure took a scant 40 seconds. "It took us a good six months to get those procedures down pat," recalls McIvor. "Then we had to learn how to adapt the aircraft to firefighting procedures we knew would work."

In the early days, when the tankers and crews were fighting more operating problems than fires, doubters said the company wouldn't last five years. With the early loss of two irreplaceable ships, that prognosis seemed likely. On a calm, sunny day in 1961, horrified observers watched as the *Marianas Mars,* piloted by an ex-service flier, approached too low to turn out of its bombing run.

The Martin Mars

While the Mars is certainly a roomy aircraft, Glenn Martin's commercial dreams for the behemoth never materialized, despite his attempts to market it as a civilian airliner. In company literature that touted the Mars' amenities, the men's lounge possessed the "simple comforts, easy convenience and elbow room most men hanker for." Likewise, the ladies' lounge had the "little niceties and luxuries which have such appeal to the distaff side."

The Mars craft are on a rotating maintenance schedule: while the Philippine *is operational, the* Hawaii Mars *gets serviced (opposite). Spare parts detective Wendy Ofstie (top) tracks down crucial hardware so Roy Copeland (above, standing) and maintenance manager Barry Simpson can keep the aircraft flying.*

The water never dropped, and the port wing clipped the treetops and tore off. The *Marianas* was completely destroyed and all four crew members were killed. The broken wing hung in the trees for years like a foreboding roadside gallows, but the accident convinced FIFT management that when it came to flying a Mars, terrain familiarity was just as important as flying competence. Since then, FIFT pilot applicants must have 7,000 hours in floatplanes or amphibians in and around B.C.'s coast.

Little more than a year later, Hurricane Frieda smashed into the southern coast of Vancouver Island, where its winds destroyed the *Caroline Mars*.

"They were tough times back then. Management spent the first 20 years trying to make the company work and pay its way," says Tom Irving, FIFT's general manager. A hands-on aeronautical engineer and former lieutenant colonel in the Royal Canadian Air Force, he makes sure that his technicians have the gear they need to keep 'em flying and that his pilots and aircrews are well drilled in their specialty. FIFT's four pilots rotate on the Mars and the Grumman Goose lead-in airplane so that they are proficient with both types of aircraft. Technicians are cross-trained on the Mars, Goose, and FIFT's three Bell helicopters, enabling them to make all repairs except major engine overhauls.

FIFT uses the helicopters for medevac, personnel transportation, and daily fire spotting patrols. The helicopters tote 145-gallon "Bambi buckets" to suppress spot fires before they take hold, work the Mars craft had to do in McIvor's day. Otherwise, FIFT firefighting procedures have not changed dramatically. On a fire call, the Goose (another veteran, dating back to 1944) is aloft within minutes and sets up contact with the fire boss on the ground, who is en route to assess the fire's size and nature. Meanwhile, the Mars is warmed up and making its first water pickup. Circling over the blaze, the Goose briefs the Mars pilot on circuit altitude, drop height, and exit plan and leads him in for as many drops as it takes to quench the flames. "We can get water on that fire in anywhere from 35 to 48 minutes, and we can hit it as many as 30 times in a six-hour sortie, and we won't stop until it's secure," says Irving.

The tankers have more than justified McIvor's faith in their potential. They have quelled as many as 40 fires in a single year, saving millions of dollars' worth of timber—to say nothing of homes and, possibly, lives. The Mars tankers have smothered remote fires that would have taken ground firefighters a week to muffle—if they could even

reach the blaze at all. A rash of fires may mean a dozen or more calls for the Mars, and Irving is charged with making the critical decisions as to which takes precedence. "My first responsibility is to our three member companies," he says, "but I work on a list of 'values at risk,' at the top of which is human life. I'll send the Mars in immediately when a fire boss confirms an interface fire—one that threatens homes and lives."

Ideally, the crew dumps its 7,200-gallon load, laced with 28 gallons of foam concentrate to ensure deep soaking, smack into the tremendous vacuum just behind the fire so that the water is sucked into the vortex for maximum saturation. If it's dropped on top of the fire, the intense heat will evaporate much of it before it hits. "It becomes second nature to you after a while," says Jack Waddington, 46, a slim, diminutive man who barely seems to have the body weight required to manhandle the Mars through tall timber. "All you have to do is know your altitude and judge

the wind, and you should be bang on every time." And avoid the smoke, hold her steady, and buck the turbulence—just like you would on a low-level World War II bombing run, with the treetops substituting for flak. And instead of making only one pass, you might make two dozen or more.

"On a long bombing day you're running on adrenaline," explains Reg Young, 52, a Haida Indian from Queen Charlotte Islands whose indigenous calm is so deep that a casual observer might think the man doesn't have adrenal glands. "It's a real physical workout—20 to 25 drops a sortie, two sorties a day," he says. "That's a lot of pickups with no breaks. It's very demanding on expertise. You're always close to the ground, in a thermal from the fire, or operating in terrain turbulence. And you're alert all the time you're in that aircraft. There's no room for error in this business. You know you're not gonna walk away from a mistake."

None of these men are cast in the Steve Canyon mold. John DeBourcier, 51, a former corporate pilot who loves "old airplanes and round engines," looks like the guy next door, whose greatest hazard is tangling with the power mower. He acknowledges the risks but downplays them. "After all, we've been in the flying business all our lives, and we go

Pilots Jack Waddington (right, seated in the bow) and John DeBourcier are members of an elite group: only four people in the world are certified to fly the Mars. The crew of four is rounded out by a flight engineer and a flight mechanic, who control the engines and monitor hydraulics and pump switches at a console 30 feet behind the flight deck (above).

Its classic shape reminiscent of Pan Am's Martin Clippers, the Mars (top) is being flown in a manner it was not designed for. It takes a highly experienced pilot to maneuver such a large, heavy craft through smoke-filled, turbulent air at low altitudes. Would-be Mars pilots must have 7,000 hours flying waterborne aircraft around the British Columbia coast. Still, Jack Waddington (above) had to apply five times before he was hired.

The Sproat Lake base (opposite) may look calm, but during the summer fire season FIFT employees are ready for action. If they get a call, the Mars pilots can reach a fire in 30 minutes.

into conditions and situations we know we can tolerate. We all have families we want to come home to," he says.

DeBourcier holds the record for consecutive drops: 37 in a single five-hour sortie. Waddington, who applied to FIFT five times before he finally got hired, credits teamwork and flexibility for the group's airborne dexterity. "Everything is procedurized," he says. "We're right down there on the line in reduced visibility and cranky terrain, and we know what to do if we suddenly lose a critical outside engine." Hugh Fraser, 48, an avid skier, voices a thought that is meaningful to all of them: "We're all throwbacks. Aviation has kinda passed us by."

Not quite. "These guys are a unique group," says dispatcher Deb White, who works with the pilots daily. "They're the only four men in the entire world who are certified to fly the Mars. Firefighting is not for kids, especially the way they do it. They're all family men. Home life for most fliers up here is almost nonexistent, but our guys are usually home every night and they get most of the winter off. The pay and the benefits are good and you get to stay home and live here in the Northwest. As far as aviation is concerned, this job is the ultimate."

"Sometimes we feel more like museum curators than aviators here," says Barry Simpson, FIFT's maintenance manager for 26 years. "But that's what I love about this outfit, and I think it's true for all of us. We're still in aviation as it used to be. You fly by the seat of your pants, you think for yourself, and if it breaks, you *fix* it."

Servicing the Mars is like putting a dinosaur in intensive care. The key surgery is carried out in hospital-clean hangars and machine shops under the watchful eye of Mars chief engineer Roy Copeland, a 13-year FIFT veteran who also flies regularly as first engineer on one of the three operational crews. He is a man who leaves nothing to chance. The two Mars craft are on a rotating four-year maintenance schedule that includes in-depth inspections of the engines on each aircraft every year and an overhaul of all vital airframe elements. Technicians constantly watch for corrosion and metal fatigue. They peel back leading edges to the front spar for inspection and structural reconditioning. They run stress tests on key linkages, and if the technicians cannot replace a part, they make one from scratch. (It goes without saying that they never discard original pieces.)

What they can't make, however, is propellers, and Simpson is currently worried about replacements for the Curtiss Electric 830-21C4 or 830-26C4 airscrews needed to keep the Mars craft flying. "They were also used on the old 749 Constellations," he says, "and if any turn up, they're usually attached to a Connie and you have to buy the whole airplane." Wendy Ofstie, FIFT's purchasing specialist and spare parts detective, oversees a vast repository of

antique and reproduction parts and has amassed a three-inch-thick file of exhausted leads. She is showing signs of intense nervousness.

The tiniest flaw can ground one of these mammoths indefinitely. On a recent service check of the *Hawaii*'s control system, hairline cracks were discovered in random links of the chain that operates the ailerons, where inflight breakage could cause a disaster. "The chains were cadmium-plated," says Simpson, "and in this case, a worker didn't do his job correctly 50 years ago. When he cleaned the metal plating, he didn't make sure that the cleaning solution was totally removed. Cleaner residue was sealed in under the cadmium and over time attacked the metal to produce embrittlement."

Simple solution? Get new #35 chains. Problem? They don't exist. Simpson traced the specifications and primary manufacturer from the original master drawings and files only to find that the company had been taken over years before. His query to the current owners elicited the following reply: "Closest we can come is #36. Sorry, but this ain't a place to restore antique aircraft."

"They did suggest that we go to a double chain, which I could buy by the mile," says Barry. "And in the end there was no alternative. In our tests, the cracked links snapped at 1,100 pounds. We simply couldn't find a single chain with the same 2,395-pound breaking strength as the original, so we had to make a double sprocket to take the new chain and then modify the control column to take the new sprocket." And the *Hawaii* flies again.

Their pilots wish they could fly her and the *Philippine* more often. "Four hundred hours of flying time split between the four of us doesn't amount to much," says Reg Young. He had 15,000 hours in amphibians and floatplanes when he joined FIFT eleven years ago, but has logged only 3,000 since then. "There's no ferry time," he explains. "We don't sit up there above the clouds all day looking down at the tops of them. We're flying on the line. But who cares? This job's got everything I want—the excitement of fighting fires, the people contact, the machine, the terrain. I've never lost interest. None of us have. We're all the same, eh? When the siren goes, everybody wants to be the first one out."

Dan McIvor would understand. Now 82, he lives in Vancouver, close enough to Sproat Lake to take a day trip out whenever he feels the need to look at a Mars. "My whole flying life reached its climax in that aircraft," he says. "They're just beautiful airplanes, and they proved me right. In 30 years they've never let a fire get away from them, and there were times when a fire boss would tell me that nothing in the world could have put out that fire but me and my Mars. And then I knew that I was the best in the world at fighting forest fires, and it was the Mars that made that possible. The best in the world. What more can a man ask?"

Absolutely nothing. Except perhaps for a Curtiss Electric 830-21C4 or 830-26C4 propeller or two. If you happen to know where to find one, call Barry Simpson or Wendy Ofstie right away at (604) 723-6225. Collect.

For All Who Share Our Goals

John M. Logsdon
Director,
Space Policy
Institute,
George
Washington
University

When President Reagan extended an invitation in 1984 to other nations to help build space station Freedom, he said that such a collaboration would "strengthen peace, build prosperity, and expand freedom for all who share our goals." Canada, Japan, and 10 European countries accepted that invitation, believing that it would let them participate in a project that would be central to space development and exploration in the next several decades.

Ongoing problems in the space station program, however, have sent a message that runs deeply contrary to this leadership initiative. The past few months in particular have been very trying for those countries who agreed to join the United States in this largest-ever experiment in international technological cooperation. During the program's recent struggles through successive redesigns, managerial changes, and razor-thin margins of approval by Congress, the United States' international partners have seen their multibillion-dollar investments put at risk and have had their faith in the United States as a partner in major cooperative undertakings badly shaken.

It's too late to make the station program the successful U.S. leadership initiative that was anticipated in 1984.

The United States has a great deal in jeopardy as well. For three decades cooperative displays of its space goals and capabilities have served as a visible tool of American propaganda, communicating an image of a pioneering country on the technological, managerial, and political cutting edge, a country in pursuit of ends that were in the common interest. Such an image supported the U.S. claim that it was worthy of the leadership position in space and, indeed, international affairs in general.

It's easy to see that the space station program to date can be viewed not as a demonstration of U.S. leadership but as an example of America's inability to set widely respected goals and mobilize the resources needed to accomplish them on a sustained basis. NASA's difficulties in demonstrating a compelling justification for the station and in devising a station design and management scheme that command broad technical and political support certainly have not reinforced an image of the U.S. space program as reflecting the best of American society.

Nor has NASA's behavior always been that of a managing partner sensitive to the interests of its associates. Within a year of signing international agreements that included specific station characteristics such as the number of crew and the power available for the partners' laboratories, NASA changed the facility's design without consulting its partners. Since 1989 the U.S. portion of the station has gone through four more redesigns, each moving further away from the agreed-upon parameters on which our partners were basing their planning. In each of the last three years, Congressional moves to cancel the station program have sent shock waves through the governments and industries of the partners, whose contributions would be useless without the U.S. station core.

While major space station program changes designed to produce a sounder, more affordable design are presently under way, the program still faces many unknowns. At the time of this writing, NASA is considering various levels of participation for a new international partner: Russia. This would represent a fundamental shift, not only in the station program but also in the way that many other future space undertakings are likely to be organized. Rather than U.S.-U.S.S.R. rivalry being a primary driver of U.S. space policy, Russian-American cooperation could be the centerpiece of planning for future international space projects.

This further worries the space station partners, however, who fear that close collaboration between the two leading spacefaring countries could limit the influence of others on such cooperative planning. But engaging *all* major spacefaring countries in joint ventures could allow a sharing of costs and a productive pooling of resources.

It's too late to make the station program the successful U.S. leadership initiative that was anticipated in 1984. But a collapse of the

In the struggle to build a politically viable space station, has the U.S. lost something far more valuable?

partnership would have a chilling effect on the United States' abilities as an international leader. NASA has already had to walk a political tightrope as it tries to find ways to make the changes needed to reduce station costs and complexity without alienating its current international partners. And certainly existing international commitments have been crucial in rallying administration and Congressional support for keeping the program alive. But the idea of including Russia as a major partner, both to reduce overall program costs and to signal endorsement of the current Russian government, also has strong White House support. So for now, the high-wire act must continue, and now it's more critical than ever.

The partnership's problems in adjusting to the end of the cold war, lowered ambitions in space, and constrained government budgets among all station partners should not be allowed to obscure the long-term benefits of international cooperation in space. Cooperation is the best, and in some cases the only, way of carrying out many of the valuable undertakings on the current and future space agenda. While the precise character of the space station program, including its international aspects, is likely to remain in flux for some time, it is important that nations continue to plan for increasing collaboration in space science and applications and, eventually, in developing other parts of space infrastructure and resuming human exploration beyond Earth orbit.

No one—not the current partners, nor Russia, nor the United States—will be completely satisfied with the outcome of the station redesign process. But the bottom line is that the station program *is* going forward as an international venture: it is important to learn what positive lessons we can from the station experience, and to put its negative aspects aside in planning for the future.

In that planning, the United States should work with other spacefaring countries from the start to identify common objectives and collaborative approaches to achieving them; in that way, confidence in America as a cooperative partner will gradually be rebuilt. For example, even before the recent loss of the Mars Observer, such an approach was being followed in planning missions to Mars.

The United States has consistently used its civilian space program as a source of what political scientist Joseph Nye has labeled "soft power"—the ability to influence, without resorting to coercion, the behavior and decisions of other countries and peoples. Such power is based on others following the U.S. lead because they admire and want to share in its values, culture, and accomplishments; by possessing a reservoir of such goodwill, the United States can help shape the course of international affairs without threatening to use force or other coercive sanctions.

Problems in the space station program have damaged this ability, but the repair process is already under way, as NASA administrator Daniel Goldin carries out President Clinton's directive to "redesign NASA." Reconstituting the space station program in a way that reflects current interests and budget constraints around the world is an essential part of this process of change. The United States should get some credit for facing up to this unpleasant reality, however difficult and unpopular that task has been.

If the United States is to have a leading role in shaping the cooperative partnerships of the future, it must first develop a space program of its own that is built around widely shared goals, reliable and cost-effective capabilities for achieving those goals, and excellence in the use of those capabilities. Such a program will provide the stable foundation needed for effective U.S. involvement in future cooperative ventures. U.S. leadership in international space, and indeed in international affairs overall, must be earned, not merely declared. Getting the space station program on a sounder basis is a major step in that direction.

U.S. leadership in international space must be earned, not merely declared.

Flier's Market

New niche airlines are adding a little variety to a depressed industry.

by John Grossmann

The U.S. airline industry has been smitten by the ancient Chinese curse "May you live in interesting times." In just the last three years U.S. carriers have lost $9.6 billion—more money, airline executives keep pointing out, than the industry has made in its entire history. Yet in the midst of continuing bleak forecasts, rarely a week goes by that somebody doesn't apply to the Department of Transportation to start a new commercial airline. "Right now we have eight applications for scheduled passenger airlines," says spokesman Ed O'Hara, ticking off wannabes like Frank Lorenzo's ATX, Inc., initially

named Friendship Airlines, which has asked to fly out of Baltimore, and another called Eastwind, seeking to connect Philadelphia with Boston and Atlanta. Since 1991—the year Eastern, Braniff, Midway, and Pan Am all shut down—11 new commercial carriers have been licensed to fly.

So far, these newcomers represent at best barely a blip on the nation's radar. Their combined fleets total only several dozen airplanes, a fraction of the 680 aircraft flown by American Airlines, the nation's largest carrier. They currently transport perhaps one percent of all commercial air passengers. But at least they are making things interesting again, for in recent years the major carriers have become nearly indistinguishable. It's somewhat refreshing to need a scorecard to keep track of all the new players, who may help the industry as a whole by kicking some life into the rickety oldsters (see "New Kids on the Ramp," p. 72).

Each has a distinct personality and mission, but all face the same uncertainty: Will they find their niches and keep them, like the famed Southwest Airlines? Or, like such past failures as Midway Airlines and People Express, will they die young?

"I would expect about one-third of the new startups would survive, unlike the '80s, when not one new carrier made it," says Julius Maldutis, an airline analyst at Salomon Brothers, a Wall Street brokerage. Maldutis envisions a certain amount of cooperation between the Goliaths and the Davids of the airline industry. He believes that as the majors abandon many of their shorter routes, which have become unprofitable because of high overhead, they'll perhaps use the small carriers that replace them as feeder airlines to their money-making longer hauls.

And startups enter the competition with an advantage over the majors. With a deep pool of out-of-work flight attendants and pilots to choose from and, as yet, no unions to battle, they can pay substantially lower salaries. Flight attendants at Nevada's Reno Air, for instance, earn $13 an hour their first year, more than $3 less than first-year attendants at American and $1.75 less than those at Northwest. "It's good there are more jobs, but are they jobs worth having? Can people make a career out of them? We think not," says David Melancon, spokesman for the 33,000-member Association of Flight Attendants. But startup management clearly views such labor savings as an important part of the competitive equation. "It's imperative that a new carrier have low-cost and entry-level wages. I believe that can be achieved with or without unions," says Reno Air chief executive Jeffrey Erickson.

Startup airlines in search of direction need look no further than Southwest Airlines, a bright guiding star in an otherwise dark sky. While the major carriers continued to bleed money last year, Southwest soared, earning $91 million on total revenues of $1.6 billion. Its formula: low fares, no meals, no seat assignments, short flights, quick aircraft turnaround, upbeat marketing, and carefully targeted expansion. Now 22 years old, the airline added only two destinations in 1992 and will add only three this year (Louisville, San Jose, and Baltimore, its first city on the east coast), for a total of 37. Its niche has become a big one. Many smaller niches beckon—all rife with hazards. One 1993 start-up, Houston's UltrAir, has already shut down.

"Are they going to make it? Most of them, no," says longtime industry consultant Morten Beyer, president of Morten Beyer and Associates in McLean, Virginia. "On many routes I see too many planes chasing too few passengers." Beyer also worries about the baseball manager syndrome: rather like teams that hire each other's fired managers, many new and proposed airlines are headed by recycled airline executives. "I've seen very few airline executives who've had a significant capacity to learn," Beyer says. "No, I'm not a sourpuss. I hope they do learn. I'm a flaming advocate of new airlines. I would ride on them whenever I had a reasonable chance to. But I wouldn't invest a dime in them."

PHIL SCHERMEISTER

Last year 430 million passengers flew U.S. airliners on domestic routes. How many of them will try the industry's new entrants? For airlines just starting to look for customers, the future is anything but clear.

DAVID NANCI

An UltrAir 727 stands grounded near its vacant terminal as a Continental jet moves into position for departure.

In happier days, Barney Kogen and Gordon Cain prepare for their airline's inaugural flight (opposite).

Fun While It Lasted

UltrAir wasn't the first airline to target business travelers who cared more about comfort than cost. In past years, St. Louis-based Air One, Hollywood's MGM Grand Air, Air Atlanta, and Regent Air of Los Angeles all tried to sustain regularly scheduled flights with exclusively deluxe service. Knowing that these carriers all failed and keeping the model of no-frills Southwest in mind like a compass bearing, most fledgling airlines hope to compete with the industry giants primarily on the basis of cheaper fares. Not UltrAir. Former CEO Barney Kogen thought that for his city, Houston, the time had come for a luxury liner. You'd have a hard time convincing the passengers who flew on one of UltrAir's five 727s during its six months of operation that Kogen was wrong. "I don't know what happened. You couldn't beat it," a passenger on UltrAir's final flight who also happened to be an investment banker told the *Houston Chronicle*. "This airline should have worked."

UltrAir won such enthusiasm by providing knock-your-socks-off service and food at precisely the same fare that Houston rival Continental charged. Coach on UltrAir could have easily passed for first class on other airlines. Most airlines pack 130 or more seats in back of the curtain on their Boeing 727-200s; UltrAir had 72. Flight attendants offered hot towels on takeoff and before landing, poured vintage cabernet sauvignon and chardonnay and cocktails gratis, and dispensed pumpernickel-raisin rolls with tongs from breadbaskets. No clunky serving carts blocked the aisle. Food and beverages were carried by hand. Linen napkins served as tablecloths. The menu, offering a choice of, say, stuffed veal or homemade tortellini, had been created by nationally ranked Houston restaurateur Tony Vallone. Radicchio, hearts of artichoke, and goat cheese graced the salad. A basket of cordials appeared with coffee, which was served in china cups. There was even a single long-stemmed yellow rose (a reminder of the airline's Texas roots) in the bathroom.

Kogen believed that Houstonians would support a luxury airline. As the previous owner of the nation's largest privately held travel agency, a $1.3 billion-a-year Houston empire called Lifeco Travel Services, Kogen booked the majority of local corporate air travel for more than a decade. He said he knew the precise number of people who fly from Houston to Newark.

He also said that Houstonians deserved a luxury airline. "This city has been very good to me and my partner, Gordon Cain, and we both feel if you take from a city you give back," said Kogen. (Cain, a former Conoco executive with business holdings and a personal fortune far greater than Kogen's, put up the major portion of the $5 million it took to found UltrAir.) The airline, he explained in his Houston office last spring, had a human side and a business side. The human side had everything to do with Houston and was couched in charitable sentiments. The business side was pure, opportunistic predation.

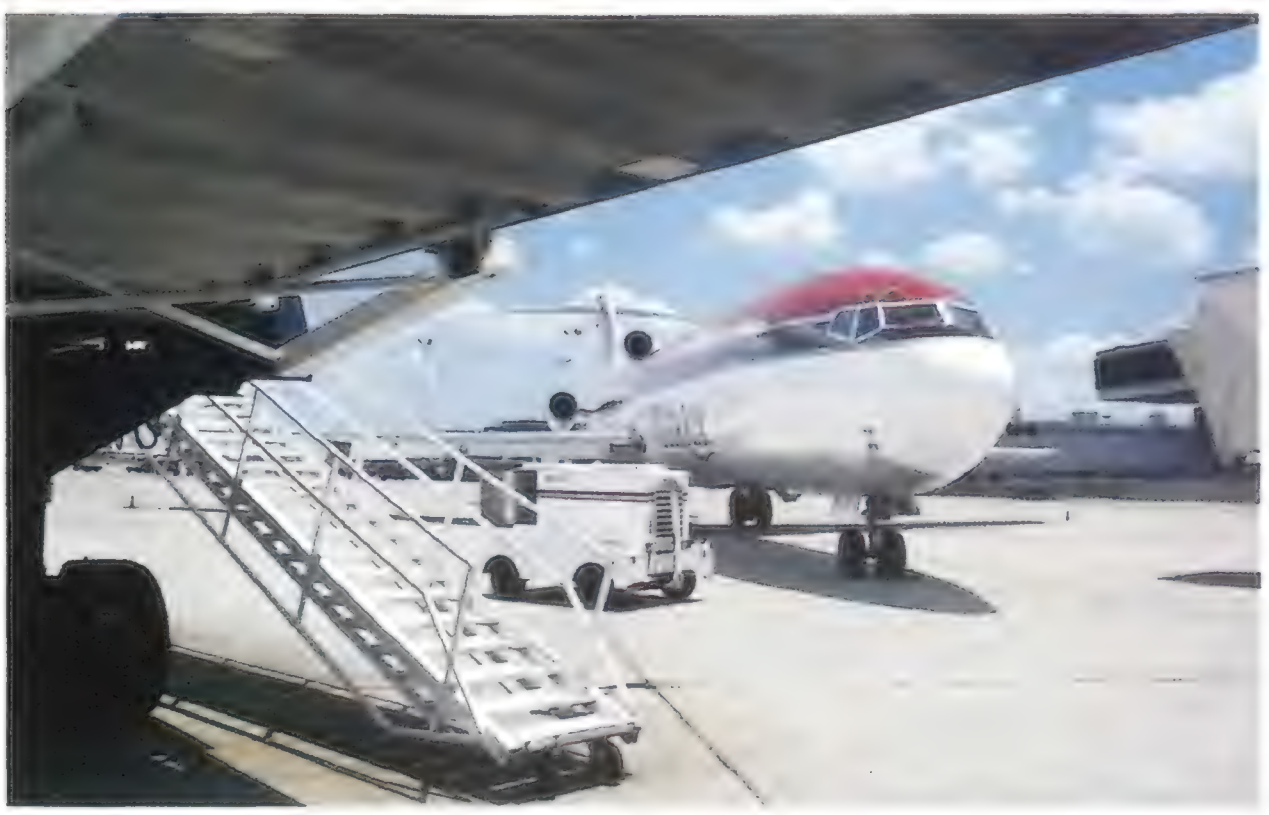
"Here's the entire key to UltrAir," he said when the airline was three months

HOUSTON CHRONICLE

UltrAir's last passenger boards flight 532, which traveled from Houston to Newark on July 25, 1993. There was no return flight. After six months of chronically low passenger turnout, UltrAir went out of business.

HOUSTON CHRONICLE

An empty gate (above) and deserted ramp (below) argue forcefully against exclusively first-class service.



old. "We have taken an industry that has been traditionally 90 percent fixed costs and converted it to roughly 80 percent variable costs. We only pay for what we use." How? By taking advantage of every opportunity washed ashore by the shipwrecked industry. Airplanes? Easily had, in this buyers' market, for reasonable short-term leases. Pilots? Only too willing to be paid by the flight at $60 per hour. UltrAir stocked no inventory of 727 parts. It had no mechanics. No baggage handlers. No gate agents. "The ones you saw in Newark and Houston—they work for American Airlines. We rent those people by the departure," Kogen laughed. "They simply change scarves."

UltrAir maneuvered another arrangement with American Airlines. Knowing the allure of frequent flier programs, Kogen wanted to entice passengers with bonus miles but without the enormous cost of setting up his own program. He also knew that UltrAir's unglamorous Houston-to-Newark route was not the stuff of free dream vacations. So he cannily pioneered a deal that awarded UltrAir's passengers frequent flier miles in American's Advantage program and paid American two and a half cents per mile. This incentive was costly, however, especially since the airline gave away 5,000 of those miles to every first-time customer.

Such bonuses must have cut deeply into the savings UltrAir realized by piggybacking on the majors, and when the traffic that Kogen expected didn't materialize, his partner bought him out and returned to charter service. Kogen had a different explanation. UltrAir failed, he told reporters in July, because of the "illegal, anti-competitive, monopolistic and predatory behavior" of Continental Airlines.

UltrAir's genteel pampering always seemed at odds with the snapping turtle of a CEO who at every opportunity for almost the entire lifespan of his airline ripped into Continental. His own employees wrote a letter of apology to their colleagues at Continental when Kogen was quoted calling his rival a "stinking, crummy airline." Reminded of that last spring, Kogen shot back, "Well, my employees better realize who's feeding them." Reaching for a cigarette that soon dangled from under

his upper lip like a single fang, he added, "If Continental keeps up what they're doing, my employees won't have jobs."

Kogen accused Continental of such dirty tricks as covering up his airline's ads in the Houston Intercontinental Airport terminal that had been Continental's turf. He complained that his rival had formed a Crush UltrAir Committee. "Talk to Lydia Borg," he said last spring. "She was on the committee. I hired her away."

Borg, however, did not last long at UltrAir. She resigned in May, when precisely this allegation, which she brands "a lie that tarnished my reputation," broke in the *Houston Chronicle.* While confirming that UltrAir signs were covered with brown paper, presumably by overzealous employees who incorrectly believed a competitor had no right to the space, Borg denies there was a Crush UltrAir Committee at Continental, characterizing the group she was part of as standard stuff, "a committee put together to respond to a new competitor," one she says was "filled with fiascoes.

"Barney's naive. He didn't think he'd have to spend a penny on advertising," she says. "He thought people in Houston would flock to UltrAir because it was his."

A fancier of fine suits, blazing gold cuff links, and silk ties as colorful as a salt-water aquarium, 50-year-old Barney Kogen is indeed a local legend, a cocksure entrepreneur with ever larger notches on his business belt that go all the way back to high school, when he sold classmates fraternity and sorority license plates. In college he peddled corsages and encyclopedias and sold women's shoes. After graduating, he opened a pool hall in Chicago, learning how to wield a cue stick to break up fights. In the 1970s he sold boats until the energy crisis hit and he was forced into bankruptcy. Next he plunked down $10,000 or so and bought a travel agency, mostly, he claims, because like everybody else, he wanted free airline tickets. That's the agency he built into the nation's largest and sold 11 years later to American Express Travel for more than $100 million.

While UltrAir was flying, Kogen got used to hearing others predict its failure. He responded once by saying he'd be plenty happy in full-time retirement plying the blue waters of the Mediterranean or Caribbean in his 78-foot sailboat, but that was difficult to imagine. Even a 78-foot sailboat couldn't provide much of a challenge, or, for that matter, accommodate much of an audience. Today he's talking about starting another airline for Houston.

It's a Wonderful Life

Three summers ago, before there was an airline irreverently named after a flightless New Zealand bird, there began a 10-month occupation of Codie Bell's three-story Victorian house in Bayonne, New Jersey. Extra phone lines were installed and long-grounded Eastern pilots and flight attendants worked shoulder to shoulder at tables crammed into spare bedrooms. Employee interviews often took place on the front porch or out back in the garden. Even Bell's wife's sewing room was usurped as a copy machine/conference room. "Because it was between our bedroom and the shower, the rule was you couldn't have a conference until 9 a.m. so my wife could take a shower," Bell recalls. He also remembers the sound of his front door being closed at daybreak by a pilot or two heading home after a night working on flight manuals to catch a few hours of sleep before an afternoon's re-training in a flight simulator.

Today, more than a year after its inaugural flight, KIWI International Air Lines still occupies cramped quarters, though they are considerably larger, located in an office building hard by Routes 1 and 9 in the fettuccine-like tangle of highways adjacent to Newark Airport. Runway 29, as it happens, points takeoffs virtually overhead. Early on, when one of *their* planes was lifting off,

A self-styled family business, the KIWI clan forms a cheering section (below) behind CEO Robert Iverson, flight attendant Karen Greenwald, and pilots Don McCoy and Ken House. Among the casualties of the '80s airline bankruptcies, KIWI workers have united under one banner (opposite).

BILL BALLENBERG (4)

Codie Bell expected to serve only as a short-term advisor to KIWI. He ended up the chief financial officer.

KIWI staff members meet in what serves as a conference room facing Newark Airport's runway 29.

so many proud KIWIs, as they like to call themselves, would press their noses to the windows that, were the building a cruise ship, it might have listed to one side. The office of president and CEO Robert Iverson is just a desk in the far corner set off from a sea of other desks and ringing phones by a big oval table—the new conference room. From here, it's impossible not to gaze out his window at the always-in-motion tableau of a busy airport.

Asked how many airline executives have this kind of view, Iverson responds, "Not enough."

Iverson, 49, also knows the view from the cockpit. He, like all of KIWI's founding gang of six—except chief financial officer Codie Bell, who left the Arthur Andersen accounting firm—is a former Eastern pilot. Meaning, a pilot whose wings got clipped in the strike-torn demise of that carrier. The group first tried to get airborne again by buying the Pan Am shuttle. Then Midway, before it disappeared. KIWI is their most ambitious plan.

"We want to be the most profitable niche carrier in the history of aviation," says Iverson. "And we want to be here 30 years from now. Confucius observed: in adversity there's opportunity. God knows this industry has been beset by adversity, so the opportunities are absolutely unbelievable. But you have to look at it a little differently."

A little differently, in this case, means a tweaking of the much-celebrated, high-spirited flight pattern of Southwest Airlines. KIWI's take: unrestricted bargain fares (for instance, $104 one-way between Newark and Chicago's Midway Airport with no Saturday night stay and no advance purchase requirements), advance seat assignments, and meals like chicken and beef fajitas or turkey medallions in a pecan crust on a bed of saffron rice and jicama. KIWI recently took top honors for innovation in a competition sponsored by the Inflight Food Service Association. Like UltrAir did, KIWI believes good food and beverage

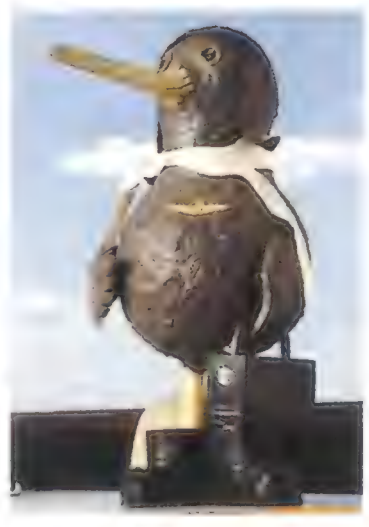
BILL BALLENBERG (4)

Customer service agents Monique Hagen and Sangeeta Thomas check in passengers, who can fly KIWI from Newark to Chicago, Atlanta, Tampa, Orlando, or San Juan. KIWI is named for a flightless New Zealand bird, which also inspired its mascot (right).

service can help win loyal customers, especially now that the majors are dishing up the incredible shrinking meal.

The game plan, Iverson explains, is to become the low-cost carrier on the east coast (notably, where Southwest did not fly until September, when it started service to Baltimore), and, by grabbing no more than about a 10 percent share in any market, stay below the competitive radar of the majors. KIWI too has had the advantage cheaper airplanes provide. "The cost of our equipment is maybe 20 percent of the majors," says Iverson, citing an approximate $49,000 monthly lease for each of its seven 727-200s.

Still, he maintains the real strength of KIWI "lies in our people, pure and simple. We are not financial wizards. But we *are* aviation people." All of KIWI's pilots and flight attendants once wore Eastern uniforms. They're joined at headquarters by a smattering of former Midway and Pan Am employees. "We euphemistically refer to ourselves as having 'mature' attitudes. We all got the hell beat out of us. Some of us lost homes, some people lost marriages. Everybody lost careers."

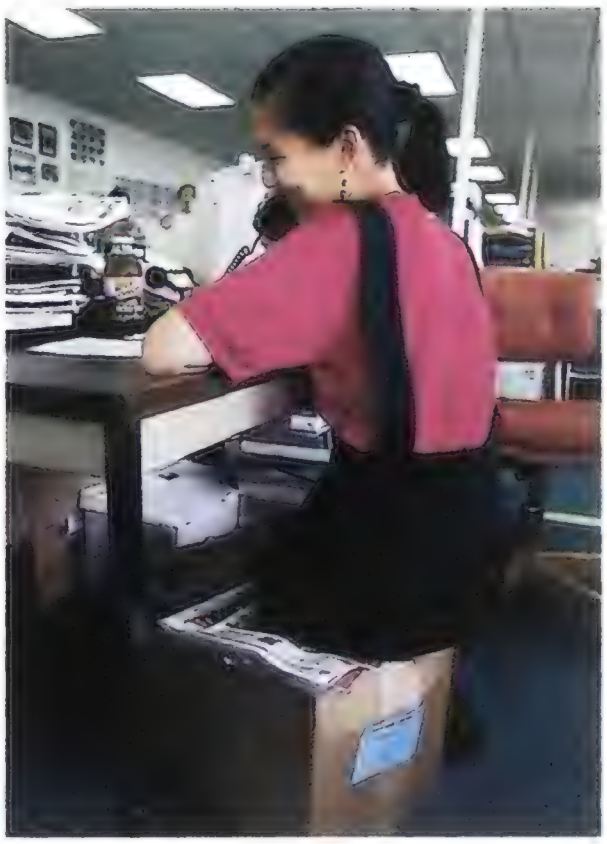


And not just any career. "There's a peculiar magnetism about the business," says Iverson. "I think there's a child-like quality to it. The airline business is like a big toy. There's something attractive about looking up in the sky and seeing this thing flying around. It's something people don't ever get over once they've had it, and when they've lost it, it leaves a huge hole."

KIWI has shrewdly capitalized on this romance, creating the airline around the concept of employee ownership. Pilots are required to invest $50,000. Flight attendants and others must ante up at least $5,000. In part because of this, the difference at KIWI is palpable: This time, the airline is theirs. This time, they'll get it right. The in-house motto: whatever it takes. Frank Capra would have loved to make a movie about KIWI.

Employee ownership is, of course, not unique to KIWI. John Bradley, an organizer for the Air Line Pilots Association, says that airline management is increasingly likely to ask employees to invest in the business. "It's the wave of the future," he says, citing Northwest Airlines as the most recent example. What seems to be unique to KIWI, however, is the strength of the collective will to prevail.

Iverson says the reason became clear to him during a recent trip to Paris, where he found himself with the airline's insurance brokers and underwriters by the Arc de Triomphe. "One of the brokers said: 'It's hard to imagine what it must have been like for Parisians to have been standing here watching the Nazis walk through their city.' I said: 'That's exactly the feeling of occupation the people of Eastern had when Texas Air and Frank Lorenzo took us.' There was a siege mentality. It was that strong. Having lost it all, it gives us a different perspective. Everybody



Some have added reason to see KIWI as a family business: Manager Michele Iverson is the CEO's daughter-in-law...

...Wayne Hendon works in accounting; his wife Gloria Vey Hendon, in customer service.

says, never again. There's a real element of recaptured dignity here. It's so strong it pervades almost everything that happens."

Employees join KIWI knowing that when they aren't busy with their primary jobs, they'll be expected to fill in as needed: answer the reservation phones, help out at the ticket counter, venture out on day-long sales blitzes—popping in unannounced at travel agencies—even give up a Saturday night to walk seat to seat aboard their airplanes scrubbing tray tables and window shades. "Instead of sitting in hotel rooms while on reserve they come in and ask, 'What can I do?' " says Greg Matuskiewicz, who coordinates the volunteers.

A more telling test of the KIWI spirit came after what's now known as the Christmas raid. KIWI had been flying four months when Continental undercut its fare to Chicago, threatening not just holiday sales but KIWI's lowest-fare niche. Customer service manager Maxine Krill spoke her thoughts aloud: "It's crazy for us to take full salary when Continental is trying to put us out of business. What good is a paycheck today if there's no KIWI tomorrow?" George Bailey at the window of his savings and loan couldn't have said it better. Everyone, except several single mothers who were told that they would not be allowed to, went on half-salary for the month of January, establishing an instant war chest of nearly a half-million dollars for counter-advertising and matching fares. A couple of pilots contributed more money to cover for those who couldn't afford the sacrifice. (Iverson and Codie Bell took no salary at all until April.)

Pilot Ken Klocek, for one, remarks that at some point the "adrenaline will wear off." Certainly KIWI will have its hands full maintaining its unique corporate culture through predicted growth from the current 490 employees to perhaps 10 times that many should the airline reach its projection of 50 airplanes by the turn of the century. But Iverson will remember for at least that long the scene in the flight attendants' training room, when he went back to the employees to announce that the company would accept their offer of a pay deferral and use the money for marketing. "I stood up in front of them and told them they'd have to go on half-pay for an undetermined amount of time until we got over the next hump. 'I can't tell you when it's going to be over,' I said, 'but if we're going to march around and say *Whatever it takes,* well, this is what it takes.'

"I didn't know what to expect. They applauded. It was the damnedest thing I'd ever seen. Within seconds, everyone in the room was crying. It was just one of those things," Iverson says, his voice trailing off, his eyes filling. He turns away, looks out the window, and instantly recovers.

"There's a KIWI plane landing," Iverson says proudly.

You Gotta Know When to Hold 'Em

Fly Reno Air and, at the end of your meal, they offer you a foil-wrapped chocolate mint that resembles a $100 casino chip. Clever marketing to be sure, but perhaps also a reminder that new airlines, even carefully targeted niche carriers, are no sure bet. Flying high in its maiden months of operation, Reno announced late last spring it was discontinuing service to its two Midwest cities—Kansas City, Missouri, and Minneapolis. Airplanes were flying only 54 percent full, and the airline needs to fill 61 or 62 percent to break even.

On balance, however, Reno Air has so far been in the chips. Beginning service in July 1992, the airline surprised even its management by showing a profit in its second month of operation. November to March, Reno flew the fullest airplanes in the skies. (Credit an assist to Mother Nature: the best winter snows in anybody's memory surely boosted the number of Lake Tahoe-bound skiers.) Its stock has soared. Initially offered at $6 for two shares and a warrant (something like a coupon for a share to be bought at a later time), the price reached $20 last February and topped $50 last spring. And that was before the airline announced two key agreements with American Airlines, both indicative of the kinds of deals and alliances today's startups will probably need to fashion to survive. First, Reno announced that it would emulate the majors and award frequent flier miles to its passengers. Like UltrAir, it bought into American's program and thus sweetened the pot for its passengers with American's farflung destinations. Second, Reno began a phased-in takeover of as many as seven of American's gates in San Jose, the start of a second mini-hub. Conceived as an airline to bring gamblers and skiers to the underserved resort destinations of Reno and Tahoe (a scenic 45-minute drive apart), Reno Air is clearly reaching for more.

At corporate headquarters, a couple of miles from Reno Cannon Interna-

tional airport, one encounters tough talk and a pragmatic, unglamorous approach to survival in the '90s. In a reception area, a pair of well-scuffed wooden chairs look as if they might have been castoffs from somebody's kitchen table. The WELCOME TO RENO AIR banner tacked on the wall behind the receptionist is a computer printout. Desk to desk, the second-hand spirit continues. Computers, carrels for the reservation agents, even paperclips were purchased at 10 cents on the dollar in the liquidation of Midway Airlines. The talk is equally ungilded.

"We're totally oriented to being profitable," says CEO and president Jeffrey Erickson, eager to distinguish Reno from the other new carriers it's typically lumped in with. "We are not a public service to the city of Reno. And we are not in this to be an employment agency for displaced airline people."

New Kids on the Ramp

All over the country new niche airlines are starting up—and shutting down. Here are a few of the new names you may see on arrival or departure boards.

Morris Air When she opened a travel agency in 1970, June Morris, now 62, could hardly have envisioned her eventual post as CEO of a commercial airline with 900 employees, 17 new Boeing 737-300s, and destinations in 25 cities. But her travel business evolved into a successful charter company, which in December 1992 was certified as a commercial carrier. Based in Salt Lake City, Morris Air offers unrestricted low fares as far east as Denver and expects to be profitable on $200 million in revenues this year.

Branson Airlines With 35 theaters attracting some eight million visitors, Branson, Missouri, has become a midwest mecca for country music lovers. The jarring note: traffic jams on the two-lane highway from Springfield (the nearest airport), some 48 miles away. To bring air service to Branson, the airline has spent more than $1 million to upgrade facilities at a small college training field a mile out of town. On July 16 the airline began flying four 50-passenger de Havilland Dash 7 aircraft, each with a big musical note on the fuselage. One-way fares: $99 from Kansas City, Missouri, and St. Louis; $129 from Nashville and Dallas.

Private Jet As a charter service, Atlanta's Private Jet Expeditions flew tours to the Caribbean islands, news organizations to Waco, Texas, and Madonna to various stops on her Blonde Ambition tour. Private Jet started regular passenger service over Miami-Atlanta-Chicago routing on May 17, 1993, because, says spokesperson Beverly McCannon, "the market for affordable seats was there." One-way walk-up fares to and from Atlanta are $99; between Miami and Chicago, $119. Saving its 64-seat 727 for charter clients, the airline flies 165-seat MD-80s.

Family Airlines The only startup to propose coast-to-coast service, Family ran into trouble when former chief executive officer Barry Michaels was sued by his investors, approximately a hundred former TWA pilots who were to be employed by the new airline. Because Michaels failed to disclose previous lawsuits and a mail-fraud conviction in his application for charter, the Department of Transportation denied Family Airlines permission to fly until Michaels gave up ownership. Family president Lance R. Carter, a former TWA executive, expects the company to begin operating this year between Los Angeles, Las Vegas—where the company is based—Miami, and New York and plans to offer a Los Angeles-to-New York round trip unrestricted fare of $249.

ATX, Inc. Formerly known as Friendship Airlines, ATX, Inc. continues the saga of Frank Lorenzo, the controversial airline executive who presided over both Continental and Eastern when those airlines sank into bankruptcy amid union-management acrimony. Lorenzo's petition to license a new discount-fare carrier to link Baltimore-Washington International Airport with Boston and Orlando provoked letters of protest from labor organizations and more than 100 members of Congress. The Department of Transportation referred the matter to an administrative law judge, who had not ruled when this magazine went to press.

Smokers' Express Perhaps the ultimate niche airline, Smokers' Express won't be an airline at all but a travel club, a distinction that will get around the FAA rule prohibiting smoking. Plans are to fly members, who pay an annual $25 fee, on regular flights from Florida's space coast to destinations like Atlanta and Dallas.

PHIL SCHERMEISTER (3)

CEO Jeff Erickson instructs a group of new reservation agents in Reno Air's corporate philosophy (opposite), while flight attendants learn their way around the airliners inside and out (this page).

Since earning a degree in aeronautical engineering, Erickson, 48, has been around airlines, and quite a few of them: Pan Am and Continental in engineering posts, then Aloha as senior vice president, and finally Midway as president under chairman and CEO David Hinson. This is his first time running an airline, and, relishing the challenge, he vows not to repeat the sins of last decade's startups.

Although Erickson was not around for Midway's last gasp, he was aboard when the initially successful airline made a disastrous move into Philadelphia, a stronghold of USAir. "The decision to buy gates in Philadelphia was not mine," he says. "Let's just say the chairman and I had philosophical differences." A lot of people believe Midway might still be flying had it nestled

PHIL SCHERMEISTER (2)

Snow-covered peaks on the vertical stabilizer symbolize one group Reno Air hopes to serve: skiers traveling to Lake Tahoe. Another destination is represented by candy wrapped like casino chips and lunches served in slot-machine-shaped boxes (left).

into its niche and not overreached. "I think there's ample evidence of cases where very smart CEOs have deviated from a sound business plan and been distracted by opportunities," says Erickson, sharpening his point with a diagnosis of "ego cancer." "My board," he says, "is determined not to let that happen to this carrier."

A key member of the board is airline veteran (TWA, Frontier, Continental) Joseph Lorenzo, who first conceived of Reno Air some years ago when looking for an off-season destination for airplanes chartering skiers to Aspen. Forget charters, Lorenzo (no relation to Frank Lorenzo) realized. Underserved and pegged for growth, Reno/Lake Tahoe offered a full-blown commercial air opportunity. Although the initial hope of creatively funding the airline with commitments from local casino hotels never materialized, there was no mistaking Reno's fortuitous spot on the map: the perfect location for a hub connecting Seattle and Los Angeles. A penny-pinching startup could easily steal passengers from the majors and, with lower fares, even stimulate traffic. Southwest had proved that. But even more encouraging: the major carriers were announcing an eagerness to jettison many of their short-haul routes, routes that were bleeding them because of their high costs.

The time was right. Reno launched with a business plan that both copies Southwest and doesn't. "We offer basic transportation with a few twists, a few market differentiations," explains John Campbell, Reno vice president of marketing and sales. "Our price gets them, our service keeps them." Unlike Southwest, Reno flights are bookable in all computer reservation systems and are thus more travel agent-friendly. There's also the option of first class—a must for casino-bound high rollers—and advance boarding passes for all. And a good bit more than goobers to munch on.

"We're not a peanut airline," says Campbell in a direct slap at Southwest, whose in-flight menu begins and ends there. Instead, coach passengers have received a bagged and more recently boxed (like a slot machine) meal containing a sandwich, a bag of chips, a

PHIL SCHERMEISTER (4)

Casinos and nightlife attract travelers to Reno, Nevada. Reno Air is hoping to cash in on some of that traffic with attractions of its own: home-cooked Nevada specialties (below) along with bargain fares.

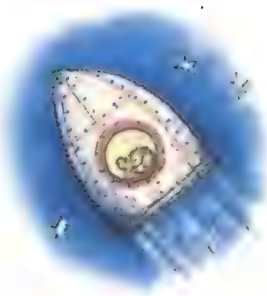
small jar of salsa, and a brownie. A picnic-like basket of mostly Nevada-made goodies is set in front of first-class passengers. Reno assembles these meals in house, forgoing the expense of a caterer. It has also held down costs by tapping the talents of executives' wives. Cheryl Reding, wife of vice president of operations Robert Reding, created the basket service, and Anita Erickson designed the first flight attendant uniforms, complete with western jackets and string ties. Although Reno appears to be leaving those small company touches behind as it has grown to more than a thousand employees and expanded up the street to a second building, it's still a relatively small airline.

The key question appears to be: How big a jackpot will Reno chase? Signs of ever increasing stakes abound. Executives are quick to quote the percentage of passengers flying through Reno, having booked the airline with other destinations in mind (as high as 29 percent before Kansas City and Minneapolis were shut down). The airline has attempted, so far unsuccessfully, to secure slots and a foothold at Chicago's O'Hare. And there's not much talk of staying pat.

"We're going to look anywhere there's an opportunity. We'd be damn fools if we didn't," says Campbell. "Are we going to get in the way of some of the big carriers? Probably. We'll grow this airline up to the point where the market says no." The San Jose expansion, Erickson admits, will begin to put Reno in direct competition with Southwest. He admits to no fear. "Our fare levels are already at their levels right now," he says. "There's plenty of traffic out there. There's no reason both carriers can't be profitable."

Southwest too is working on its competitive stare. "We're not alarmed by them coming into San Jose. We think we have a superior product," says a spokesman. But Southwest won prominence by competing with larger carriers. How it fends off a new crop of startups will make the future interesting for both carriers and passengers.

As Reno Air heads into San Jose, it will face an important test: competition with Southwest Airlines.



Davis & Able

The strange tale of a doctor and a dead monkey.

Illustrations by Richard Thompson

by A.H. Saxon

It's a bit of a shock unexpectedly coming face to face with an acquaintance one hasn't seen for over a quarter of a century, especially one who's been dead all that time. Yet there she was, looking more lifelike than when I had last seen her: meticulously preserved, wearing her tiny helmet, strapped into the custom-made fiberglass couch that had carried her into space in the spring of 1959. The setting was the Smithsonian's National Air and Space Museum, and the exhibit that had so startled me was Able, the six-pound rhesus monkey the Army had blasted off from Cape Canaveral in the days when America was gearing up for its manned space program. Able's sudden death following an otherwise perfect trip inside a capsule in the nosecone of a Jupiter rocket, aside from raising doubts about the safety of such flights, had been the unmaking of one individual's reputation—and the making of another's.

My own connection with these events came about as a result of having been drafted the year before into the peacetime Army. After completing basic training at Fort Knox, Kentucky, I was assigned to the Army Medical Research Laboratory, which was then on the same reservation. Since I had a background in biology and some experience in medical research, this seemed the logical place to employ my talents, and I soon found myself one of a team of physicians, Ph.D.'s, and enlisted men with similar interests in the laboratory's environmental medicine division.

The atmosphere at AMRL was fairly congenial, with regular hours and relatively light assignments. The laboratory was, in fact, a kind of sanctuary for college-educated recruits, isolated from the endless columns of roaring tanks and bedraggled trainees found elsewhere on the post, even though—this being the military—we had our fair share of sergeants. These last would line us up for roll call each morning, bark out a few orders and announcements to keep their command voices limber, then generally wander off and leave us alone.

Although the laboratory as a whole was a fairly big complex of buildings commanded by a regular Army colonel, the head of the environmental medicine division, which occupied the largest building, was a civilian who went by the name of Dr. T.R.A. Davis. He was a most engaging person, in his early 40s when I met him, with rugged good looks, a dark complexion, and coarse, rather wavy hair. Fairly tall and powerfully built, T.R.A.—the "T" stood for Thomas—was one of the most fascinating indi-

viduals I have ever met: a flamboyant, Barnumesque figure who, since he had no military rank and therefore was not required to play at being an officer, had no hesitation about socializing with enlisted men. Indeed, I sometimes suspected he preferred our company to that of the medical corps officers under his supervision, since they would have hardly tolerated some of the stories he regaled us with.

The doctor's tale of how he came to the United States had a typically mythical flair. Davis was of Polynesian ancestry—descended on his mother's side, he proudly informed us, from a Maori chief. After completing his medical studies at the University of Otaro in Dunedin, New Zealand, he had returned to his birthplace and become a public health officer ministering to the inhabitants of New Zealand's Cook Islands.

While serving in that position, however, "Doctor Tom," or *Tom Taote,* as the natives called him, had become incensed over some social injustice and had stirred up "his people" to the point of near rebellion, thereby incurring the wrath of the authorities in New Zealand, who sent a gunboat to arrest him. But the resourceful Doctor Tom was not a man to be taken easily. The story he gleefully told us was that upon being warned of the government's plan, he had rushed his wife and children aboard a small boat he owned, headed east across the South Pacific in mid-winter, through the Panama Canal, across the Gulf of Mexico, up the eastern seaboard of the United States, and finally into Boston Harbor, where Harvard University, welcoming the rebel doctor with open arms, promptly assigned him a laboratory of his own.

Even we enlisted men found that Homeric yarn a bit hard to swallow, although Davis had indeed made his way to Boston in a schooner he had bought, with his wife, children, and a crew of two picked up not in the Cook Islands but in New Zealand. And his biographical notices do mention that between 1952 and 1955 he was enrolled in Harvard's School of Public Health, where he earned a master's degree.

When it came to experiments conducted under his supervision, some of them, I fear, were of almost equally mythic proportions. One of the more comic was a study employing a special room whose climate could be controlled to simulate either tropical or arctic conditions. The object was to see if humans could be acclimated to both heat and cold at the same time, and the men who had volunteered to participate in the experiment—our sergeants, as it happened, who received extra pay—were supposed to sit in this room in their underwear while they were alternately cooled and heated for a few hours at a time. Meanwhile, their temperatures, heart rates, and other vital signs were monitored by skin sensors and recorded on charts in an adjoining control room, from which they could be observed through a glass window.

The trouble was, whenever the sergeants began to feel uncomfortable they would insist on coming into the control room to warm up or cool down, and the enlisted men on duty there weren't about to tell Master Sergeant Cunliffe to get his butt back where it belonged. Nor was it advisable to complain to Davis or the officers, since the sergeants made it clear that anyone blowing the whistle on them would have a pretty miserable time of it from then on. "Live and let live" became the motto for that particular experiment, and as the monitoring apparatus was left running while the sergeants were drinking their coffee or Cokes in the control room, the data recorded on those charts demonstrated that it certainly was possible to acclimate humans simultaneously to cold and hot temperatures. I sometimes wonder if the Army is still being guided by those experiments, especially in these days of rapid-deployment forces.

The results of our research were routinely communicated to the armed services and, when not classified, to the scientific community at large, thanks to a small printing operation run out of the same building. After a few changes in the text and especially in the title, an article originally published in pamphlet form by AMRL might next show up in a state medical journal and, following a few more minor changes, perhaps even in some national or international publication. Thus did the reputations of those engaging in such work spread and increase beyond the confines of Fort Knox, and I must confess that my own name appeared as a junior researcher on a number of those papers.

Nearly always heading the list of authors, of course, since he was the mastermind and frequently the principal investigator for these experiments, was T.R.A. Davis.

None of this came remotely close to the public relations coup the doctor scored with Able. At the time no human being had yet been hurled into space (Yuri Gagarin, the first person to orbit Earth, did not make his flight until nearly two years later), and there was serious doubt whether anyone could stand the physical strain of such an ordeal, let alone survive the radiation exposure and all the other hazards of space travel. Before any human lives were risked, therefore, it made sense to begin with animals, particularly primates, of which we had several at AMRL. The Navy, which was assigned the duty of recovering the rocket's nosecone off the coast of Antigua, also participated in this experiment, supplying a squirrel monkey named Baker.

Just as we had attempted to keep track of the vital signs of the uncooperative sergeants, so our job now was to monitor physiological changes in Able and Baker during their historic missile ride. As one means of doing this, electrodes were implanted beneath their skin. Everyone in the country was excited over the upcoming flight; all the national media made elaborate plans to cover it. And when the great day arrived, two photographers from *Life* magazine descended on the lab, taking hundreds if not thousands of shots for hours on end of everything they could see. By then the monkeys had already blasted off from Cape Canaveral, but the plan was that following the flight they would be rushed back to their respective laboratories, where the electrodes would be removed and the monkeys examined for any ill effects.

The flight, as mentioned, came off without a hitch. A few hours later the recovery vessel had docked in San Juan, and both monkeys, seemingly in perfect condition, were on their way home via military aircraft, stopping over briefly in Washington to participate in what one reporter described as a "monster press conference." Able was then immediately returned to Fort Knox for a more scientific examination.

The first job was to remove the electrodes that had been implanted beneath Able's skin to monitor her heartbeat and other bodily functions—a simple surgical procedure that might easily have been accomplished using a local anesthetic. In order to spare the monkey undue stress, however, it was decided to administer an anesthetic that would render her unconscious for a few minutes. Unfortunately, no sooner had the anesthetic—trichloroethylene by name—been administered than the little monkey ceased breathing.

In the controversy that soon erupted over the use of this chemical, there was some talk of the Navy's knowing about trichloroethylene's lethal effect on monkeys but failing to pass along the information. Chalk it up to one more instance of interservice rivalry, we were told.

Regardless of where the responsibility for this debacle might ultimately be assigned, an unhappy T.R.A. Davis now found himself presiding over it. There were sure to be inquiries, and the nation's confidence in the safety of the manned space program would undoubtedly be shaken. Meanwhile, those two indefatigable *Life* photographers were circling the scientists feverishly working over the monkey's limp body and recording the whole sorry scene for posterity. Adrenaline was administered and other desperate measures taken in the frantic attempt to restart Able's heart.

Then Davis, while the others were standing glumly about, made a move that I have always considered truly brilliant—almost as though he had received some kind of divine inspiration. He seized the little monkey in his arms and, while the photographers from *Life* clicked away even more furiously, began giving it mouth-to-mouth resuscitation. The result was a two-page spread in the next week's issue showing the good doctor doing just that. When the magazine hit the stands, howls of laughter erupted all over the lab. For as one medical officer who was present during these events remarked, "Ev-

eryone knew Able was stone dead," with no chance of reviving, when Davis grabbed her and began "showing off" for the photographers.

Able's body was still cooling on the operating table when a message came through from the Pentagon. The colonel in charge of AMRL was ordered to "put that monkey on ice" and to appear with it, at 0700 hours the next day, in Washington. When our downcast commanding officer, bereft of Able, returned the following evening, it was with the chilling news that he had been reassigned to the Alaskan radar defenses.

But there was no punishment for T.R.A. Davis, even though he was the one who had actually been in charge of the operation. Like Able, he had been catapulted to the status of a national celebrity. (The Navy's own monkey, Baker, incidentally, not only survived the flight but lived on in Huntsville, Alabama, until 1984, when she died at the age of 27.)

So Able passed into the history books, in time becoming an exhibit in the National Air and Space Museum. Until I discovered her in the section of the museum devoted to the race to the moon, I had no idea of her whereabouts and had even forgotten that her body had been preserved. That chance encounter unleashed a flood of memories, leading me to wonder what had become of T.R.A. Davis himself.

Upon checking with a librarian at the Yale School of Medicine, I learned that the latest edition of the American Medical Association directory listed his present address as "unknown" but that an older edition of *American Men and Women of Science* had something on him. From that source I learned only that he had left government service in 1963 and gone to work as a physiologist for Arthur D. Little, Inc. of Cambridge, Massachusetts. But upon telephoning that company, I was told he had not worked there for "quite some time" and that they too had no additional information on him.

I finally traveled to a local library to see if he might be listed in the index to obituaries in the *New York Times*. Failing to find anything there as well, I asked a reference librarian whether she had any suggestions. She promptly tapped into an online computer database, and the information that was soon spewing forth was nearly enough to send me reeling. There were indeed plenty of current biographical listings for T.R.A. Davis, but in sources I would never have thought to consult: both *Who's Who* and the *International Who's Who*, for example. And what I learned there sent me home—quite uncharacteristically, I hasten to add—for a stiff drink in mid-afternoon.

After finishing with Arthur D. Little in 1971, the doctor had returned to the Cook Islands, where he set up a private medical practice and, at the age of 62, married his second wife: a native princess, apparently, named Pa Tepaeru Ariki, by whom he had three sons. He also obviously wasted no time climbing back into the political arena—this time without being pursued by gunboats, however—for he is credited in these publications with founding, in the same year, the Cook Islands Democratic Party. In essence as well as fact, he returned to his roots and assumed his ancestral role of *ariki*, or tribal chief; as the Cook Islands had achieved something called "internal self-government" under New Zealand during the years he had been away, he actually managed to get himself appointed, from 1978 to 1987, prime minister of all 91 square miles of those remote islands! For this and other services, presumably, the Honourable Thomas R. A. Harries Davis (the one-time "Doctor Tom" seems to have expanded his name every time he took a step up the social ladder) received the Order of Merit from the Federal Republic of Germany in 1978 and was made a Knight of the British Empire in 1981.

Whether he is presently racing his yacht in some idyllic tropic sea, broadcasting over his ham radio from his island home on Rarotonga, or conducting some startling experiment in "agriculture/planting"—these being some of the leisure interests listed in his biographical entries—I lift my beret in unfeigned admiration of the Honourable Sir Thomas. Here was a modern-day Odysseus who, after a long detour in unfamiliar climes and strange places, filled with many a perilous adventure, lived to return from exile and claim his place as leader. A hero, moreover, who, in a moment when disaster seemed imminent and his warrior-followers had given up hope, boldly and single-handedly snatched victory from the jaws of defeat.

Whether he really believed he had a chance of reviving Able or whether his action was an inspired piece of grandstanding for the benefit of the photographers is not for me to say. But surely the gods, if not on Olympus then atop some Polynesian volcanic isle, must have been smiling on T.R.A. Davis that day, when he so dramatically captured the world's attention and achieved a kind of immortality himself while attempting to breathe life back into a tiny fellow creature. Some adventurers always make it safely home.

Seeking Guidance

NASA COURTESY DOUG GARNER

The Tiamat guided missile leaves the launch rack moments into its first flight.

When I look back on the nearly 50 years I've worked for NASA and its predecessor, the NACA, one adventure overshadows all others for me. It occurred not at the height of some technological triumph, but at the very beginning of an era.

It was the spring of 1945, and I had been working in the instrument research division of the NACA—the National Advisory Committee for Aeronautics—for almost a year. Germany's recent advances in guided missiles had spurred interest in the field in this country, and the NACA had been charged with evaluating and further developing a small Army Air Forces rocket-powered air-to-air missile, the MX570. At that time, we weren't too sure just what a guided missile was, but we knew that the Germans had them, so we figured we had better catch up if we were going to win the war.

I was totally intrigued with the notion of machines that "thought for themselves," and in fairly short order I had managed to wangle my way into the project. Around then I was told that the NACA had just completed a study indicating that a huge gyroscope mounted in the missile—now named the Tiamat—and intended to stabilize it by brute force was just not going to cut it as a guidance system. The gyro would have to be part of an autopilot rather than function as the autopilot itself. Elmer Sperry had reached a similar conclusion 35 years before with his experiments in aircraft stabilization, but history tends to repeat itself.

Fortunately, the NACA was able to acquire, through some devious and highly classified channels, a number of German autopilots designed for the V-1 "Buzz Bomb." As crude as these devices were by today's standards, their technology far exceeded anything available in the United States at the time.

Bob Gardiner, my supervisor and the person in charge of control system development, had a background in electrical engineering and was able to work out the modifications that would enable the autopilots to stabilize our missile. It was my responsibility to make the required hardware modifications and get the system up and running.

I was grateful for the opportunity. The science of automatic control systems was not very far along in 1945; otherwise, no one would have considered giving a kid with a brand-new degree in mechanical engineering the job of hammering together a guidance system for what was then an advanced weapons system.

Once the design was well in hand, the NACA decided to build a few prototypes and test them at Wallops Island, a new launch facility on the Virginia coast (see "Space Island," April/May 1989).

The first prototype, complete with guidance system and telemeter, was crated up and whipped off from our headquarters in Hampton, Virginia, to Wallops. The launch crew followed a couple of days later. "There are going to be a lot of people at Wallops for this first launch and we just don't have room for you on this trip," my division chief informed me. "You can visit Wallops later when things have settled down a bit."

"Yes sir. Thank you sir," I said, sitting back and waiting for the fact to soak in that nobody else had any notion of how to set up that control system and prepare it for flight. Before long I was back on the travel roster.

Right from the beginning, I felt at home on Wallops Island. The soft spring breeze, the wide, white sand beach spotted with little dunes, each topped with a thatch of scraggly beach grass—all were deeply reminiscent of Coronado beach in Florida, where I had spent summers as a boy.

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FROM THE FIELD

The physical layout was a bit primitive. The NACA had equipped the work area near the southern end of the island with four little wooden shacks, an even smaller generator shed, and an extremely uncomplicated sanitary facility.

A minimal launch area was located near the southeastern tip of the island, a safe distance from the shacks. It consisted of a large concrete slab with a spidery launching rack anchored at its center. Adjacent to the rack was a pole with a block and tackle for loading the missile onto the rack.

On the landward side was the blockhouse, an eight-by-ten wooden structure, open at the rear and heavily bulwarked with sandbags on the side facing the launch slab. A square wooden tube extending up through the sandbag-covered roof was equipped with a couple of mirrors to serve as a periscope, which the firing officer used in order to see what was going on at the launch pad without getting his head blown off. A wooden bench had been installed to accommodate the simple launch control panel and a couple of aircraft radios for communication with outlying camera stations.

We spent the first day unpacking our tools and equipment and preparing our guided missile for flight. The next morning we loaded our missile onto a balky old Army truck, hauled it down to the launch area, and duly swung it into place on its launching rack amid much shouting and waving of arms.

While the missile was still on the rack, both the telemetry system and our autopilot received power through "umbilical cords" plugged into the missile's belly. Just before launch, little electrical winches would pull the plugs out and the onboard systems would automatically switch over to internal power sources.

Our autopilot was operated almost completely by compressed air, and during flight a couple of high-pressure air bottles with very limited capacity had to power it. Any appreciable delay between the pulling of the umbilical plugs and the launching of the vehicle would deplete our internal air supply, and we would have to spend hours opening up the vehicle and recharging the air bottles.

For this reason, I was assigned the unenviable duty of crouching behind a nearby sand dune from which, if anything went wrong, I could dash out and replace the air hose umbilical before the internal cylinders lost too much air. This was a situation that would whiten the hair of a modern range safety officer, but we were very new at this game and really didn't know any better.

Well, the launch procedure went smoothly right up to the time those plugs were pulled. At that point a voice over the loudspeaker announced that the telemeter had gone off the air. That was my cue, and I rushed out and plugged my air hose back in.

After the telemeter crew milled about a bit, we tried again. But the same thing happened. We were all getting a little edgy, but when the electronics people assured us that the problem was definitely

Tiamat team members load a booster rocket onto the launch rack. Robert Gilruth, who went on to head Houston's Manned Spacecraft Center during the Apollo era, is at the far left.

solved, we gave it another try.

Again we made it up to the point at which the umbilicals were pulled, and again the voice announced that the telemeter had failed. I took off for the launch rack, figuring that we had wasted a lot of air and would probably have to recharge the bottles anyway. About the time I reached the missile, another voice came over the speaker, loud and authoritative: "Fire the damned thing anyhow."

I did an instant reverse and wheel-spin that would have done justice to a cartoon character. I had almost made it back to my sand dune when the booster rockets went off and my bare back was blasted with sand, pebbles, dead fish, and whatever else was lying around the launch pad.

Having survived the launch, I turned to watch in utter awe as our missile arced out over the Atlantic, its six booster rockets glowing red like a cluster of demon eyes. At about this point, however, I realized that the thing was rotating slowly about its roll axis. This was not supposed to happen! The autopilot, which used a free gyroscope mounted in a gimbal assembly as an attitude reference, was designed to keep the vehicle on an even keel. If the missile rolled further than about 90 degrees, the gyro would hit stops and completely cease to function.

Well, it rolled a lot further than 90 degrees before the booster assembly was jettisoned, and I knew that the autopilot had to be out of business. I had not even considered the possibility that the booster's huge stabilizing fins might be misaligned enough to overpower the guidance system, and evidently no one else had either. The missile continued its arc, showing no inclination to level off and fly a straight course as planned. Finally, long before its time, it plunged into the ocean.

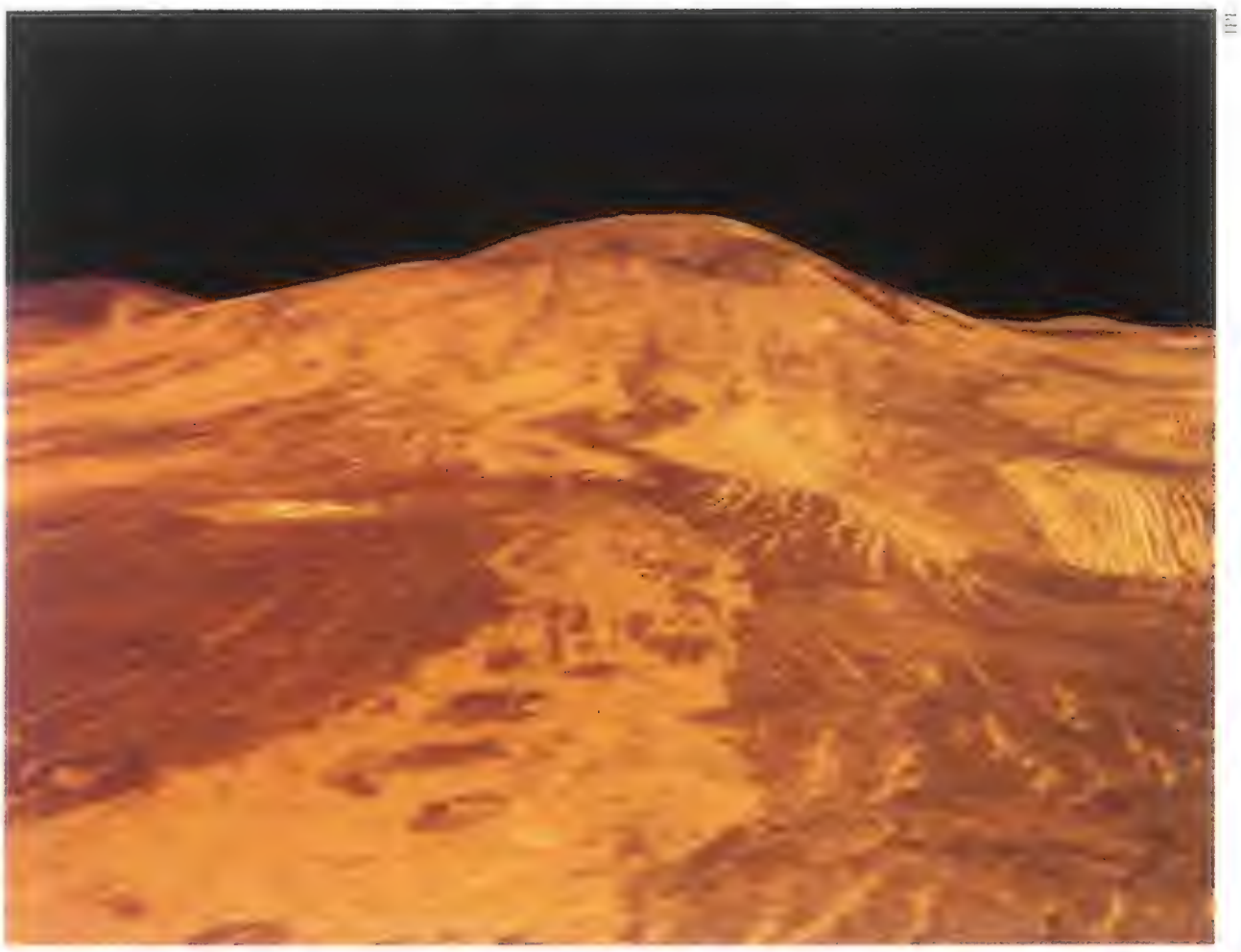
Despite the control system failure, the powers that be concluded that the flight was a great success. At that time, just getting a rocket-powered vehicle off the ground and having the booster system perform properly was considered a remarkable feat.

We went on to design and launch more successful models, and eventually our guided missile performed exactly as we intended. Then the war ended and weapons development at the NACA came to a halt. Rocket flights continued, of course, and Wallops Island played a key role in much of this progress. But it became more and more civilized as time went on, and more like the other advanced launch facilities around the country. The primitive charm that had so captivated my imagination on that first flight was gone.

—Doug Garner

Tales of Brave Magellan

The Evening Star: Venus Observed *by Henry S.F. Cooper, Jr. Farrar Straus Giroux, 1993. 274 pp., $22.00 (hardcover).*



As a staff writer at *The New Yorker* for over 25 years, Henry Cooper has been one of the most eloquent chroniclers of mankind's exploration of space. His latest book is about the Magellan spacecraft and its mapping of Venus, which Cooper affectionately describes as one of the last spaceflights of the classic era of planetary exploration, when unmanned spacecraft "of exquisite delicacy and complexity, crammed with instruments, returned data, and particularly pictures, from unknown worlds, to teams of excited scientists waiting anxiously at the Jet Propulsion Laboratory in Pasadena."

What makes this a particularly gripping story is that the author had extraordinary access to the project scientists. The result is a superb first-hand account of the Magellan scientists grappling with the bizarre geology of a world in the grip of a runaway greenhouse effect. Hidden beneath its veil of clouds, with a surface temperature of 900 degrees Fahrenheit and an atmospheric pressure 90 times that of Earth, Venus is a singularly hostile environment for would-be explorers. Peering down through the clouds with radar, Magellan mapped a new swath of Venusian landscape with each orbit.

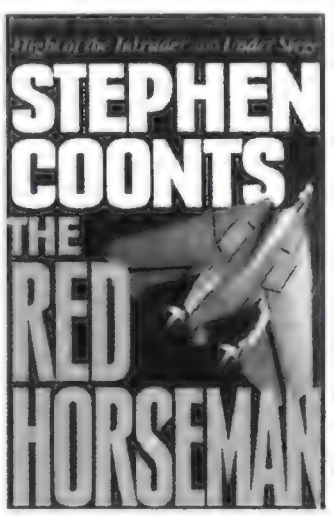
Back on Earth, scientists eagerly pored over the images, trying to make sense of them. It remains a much-debated question whether Venus has or ever had active plate tectonics, the process that shapes Earth's surface. One scientist suggests it may be more of a case of "scum tectonics"; another opts for "blob tectonics." The hellish conditions on Venus have given a unique twist to familiar processes such as cratering and volcanism, and have created a gallery of geological features never seen before—coronae, ticks, and pancakes. Cooper tracks the data and the debates in an easy, flowing style that captures the passions and frustrations of the scientists.

One of the many strengths of this excellent book is that Cooper does not neglect the spacecraft. What could have been a dry technical recitation of Magellan's many glitches is instead a first-rate detective story. Although the inclusion of some of the Magellan images would have improved the book, Cooper's words—lucid, informative, and entertaining—do the job nicely.

—Mark Washburn is a freelance science writer who lives in Acton, Massachusetts.

The Red Horseman *by Stephen Coonts. Pocket Books, 1993. 344 pp., $23.00 (hardcover).*

Jake Grafton, the pilot-hero of Stephen Coonts' thrillers, occupies a special place in my aeronautical heart. As a brash young Navy aviator, Grafton took me and thousands of others into the cockpit of an A-6 in the pages of *Flight of the Intruder*. It was an aerial domain rendered genuine by the author's own experience; one heard the expert talking. Over the years Jake has returned again and again, each time a little older and with more braid, but one step further removed from that airborne world he understands so well.



In *The Red Horseman*, Rear Admiral Jake Grafton, now deputy director of the Defense Intelligence Agency, embarks on a veritable odyssey of problem-solving: Stalinist officers are peddling tactical nukes to none other than Saddam himself. In Red Square men in business suits let loose

with machine-guns in the middle of a right wing rally. Russian officers coax a breeder reactor into blowing up with the force of a Nagasaki bomb, littering an enormous area with lethal radiation. Leave it to Jake to fix everything.

For those seeking *Flight of the Intruder*'s Grafton, you'll find him in a cockpit—a Russian one—from page 242 to page 259, where at last we hear what we've been waiting for: that expert voice. Throughout, the characters nag one another that this is not some hypothetical drill—this is the real world. Of course it is anything but. *The Red Horseman* is a fantasy of courageous Americans in uniform, hampered by cowardly bureaucrats and devious killer spooks. Reading all this in the summer of 1993, one thinks sadly of the empty skies over Sarajevo. Alas, all our courage has been expended in imagined combat; there is nothing left for the doomed victims of the *real* real word.

—Carl A. Posey is an editor at Time-Life Books in Alexandria, Virginia.

Red Sky *by Mike Mullane. Northwest Publishing Inc., 1993. 427 pp., $21.95 (hardcover).*

This is the first work of fiction about astronauts by an astronaut. After three shuttle flights the author left NASA and turned to other pursuits, but it's clear from his byline—"Astronaut Mike Mullane"—that he still considers himself one of "the brotherhood." If nothing else, Mullane's experience as a shuttle astronaut gives his first novel a certain credibility.

Red Sky is actually two tales. It's a suspenseful account of a super-secret military mission by U.S. astronauts who take off to capture a threatening Soviet satellite but end up defusing the cold war. Mullane, a veteran of two Department of Defense missions that were conducted in complete secrecy, portrays NASA as a can-do agency. But any readers familiar with today's shuttle may have to suspend their disbelief more than once before the final page.

It's also a sexy, steamy, and not-so-flattering glimpse of the private lives of the shuttle crew. Be warned: Mullane renders bedroom scenes as graphically as he recounts the sights and sensations of a space shuttle launch—a fact that prompted the U.S. Space Camp in Titusville, Florida, to yank 84 copies of *Red Sky* from its gift shop in order to keep it out of the hands of the young campers.

The story holds its own without all the sex, which seems to have been added awkwardly as an afterthought, perhaps in hopes of selling more books. The book

carries the typical disclaimer about any resemblance to real people or incidents being purely coincidental, but Mullane acknowledges the inspiration of his former crewmates, and one is left wondering how much of his storytelling is based on direct experience.

—Beth Dickey writes about the space shuttle for Reuters News Service.

The Light at the Edge of the Universe: Leading Cosmologists on the Brink of a Scientific Revolution *by Michael D. Lemonick. Villard Books, 1993. 325 pp., b&w photos, $24.00 (hardcover).*

Cosmology, the attempt to understand the structure and history of the universe as a whole, is a subject as old as humanity. But modern cosmology did not begin until the 1920s, with astronomer Edwin Hubble's electrifying announcement that the universe is expanding. Suddenly the subject passed from the realm of myth or philosophical speculation and into the realm of science. Cosmology entered a new phase with the mid-1960s discovery of the residual glow from the Big Bang—the light at the edge of the universe.

Michael Lemonick, a science writer and associate editor at *Time* magazine, has been following cosmologists around for the past several years: going with them to observatories, sitting with them at their computers, and listening to them debate at conferences. This book is the result.

Lemonick is at his best when he describes his visits to the scientists. His writing is excellent as he tells of driving across the New Mexico desert and suddenly getting his first glimpse of the gigantic Very Large Array of radio telescopes. He takes us along to lunch with a group of Princeton University astronomers, listening as they argue over the impact of the latest data on the latest theories. From these passages the reader gets a vivid glimpse of real people wrestling with real issues. Lemonick accurately portrays what it is like to be a scientist.

But entirely missing is any real comprehension of what these people are doing. Lemonick's presentation of the actual problems facing modern cosmology is weak, and far too often his treatment of the scientific issues is so brief as to be incomprehensible to the general reader. Those who wish to understand what it is that so grips the men and women interviewed in this book should read Dennis Overbye's *Lonely Hearts of the Cosmos* to learn what gives meaning to the lives of these astronomers.

—George Greenstein is a professor of astronomy at Amherst College in Massachusetts.

VIDEO

The popular IMAX film *Blue Planet*, viewed by many visitors to the National Air and Space Museum, is now available on video. Filmed by astronauts on five space shuttle missions, the 42-minute movie offers spectacular views of our planet.

To order: Send $29.95 to Finley-Holiday Film Corp., 12607 E. Philadelphia St., Whittier, CA 90601, or call (800) 345-6707.

Shannon Departures: A Study in Regional Initiatives *by Bernard Share. Gill and Macmillan, 1992. 228 pp., b&w photos, $35.00 (hardbound).*

If your local military airfield has just been declared surplus, *Shannon Departures*, by the former editor of Aer Lingus' in-flight magazine, may be just the book for you. It tells how an Irish airport turned such a misfortune into opportunity and brought prosperity to one of the world's poorest regions.

Now the anchor of a 4,000-square-mile region that is popular with tourists and attractive to U.S. computer and aerospace companies, Shannon Airport wasn't always so. Indeed, after 20 years of refueling airplanes unable to fly nonstop to mainland Europe, its life as an airport seemed over. With the new jets, there'd be no transit patrons for its restaurants and shops, leaving only birds and rabbits to roam the runways.

But Brendan O'Regan, who had developed Shannon as the world's first duty-free shopping center, had other ideas. After visiting Panama and Puerto Rico in 1958, he concluded that business could still be

pulled from the sky. Shannon, he said, would make itself as attractive to industry as it had been to air passengers. It aimed to become a duty-free area that would promote air freight and employment, give companies incentives to settle there, and develop other attractions to bring back the air traveler. Not every idea worked, but enough did to justify the optimism.

—Gerald Fitzgerald is a Washington, D.C. writer who visits Ireland frequently.

Flying the Frontiers: NACA and NASA Experimental Aircraft *by Arthur Pearcy. Naval Institute Press, 1993. 200 pp., b&w and color photos, $34.95 (hardcover).*

Amid recent calls from both inside and outside NASA for a return to aeronautics, it seems appropriate that Arthur Pearcy has written an entertaining and educational history that examines the birth of the National Advisory Committee for Aeronautics (NACA) and its transformation into a space agency. Profusely illustrated with over 200 photographs, many of which are rarely seen outside of the technical reports that they originally appeared in, this timely volume will remind readers why some still insist on pointing out what the first "A" in NASA stands for.

In the chapter "Earth Resources Aircraft Project," the author does a particularly nice job of highlighting NASA's use of the Lockheed U-2 series of aircraft. Many aspects of the U-2/ER-2 aircraft are discussed, from the ways the CIA covered up its U-2 operations in the early 1960s to the ozone mapping flights of recent years. The use of the Martin WB-57 and the Lockheed P-3 and C-130 are mentioned as well.

Pearcy's work adds to NASA's own institutional histories, but he seems a bit biased toward the agency's California facilities. While the text describes Ames and Dryden programs in wonderful detail, Lewis and Langley programs receive at times only a cursory mention. Nothing is said, for instance, of research pilot Herbert Hoover's pioneering work penetrating thunderstorms with the Lockheed XC-35 at Langley in the early 1940s. My only other complaint is that, in addition to its many interesting appendices, the book should have included an index.

—Brian Nicklas works in the archives division of the National Air and Space Museum.

TELEVISION

"The Stuff of Dreams," a three-part series that debuts on PBS stations on Tuesday, October 19, explores how new composite materials have revolutionized aviation and features interviews with Burt Rutan and Boeing's Dan Arnold.

"The Mysterious Crash of Flight 201," which airs on PBS stations on Tuesday, November 30, follows a National Transportation Safety Board team to a jungle crash site, where they try to determine what caused the June 6, 1992 crash of a Panamanian 737 airliner.

The First Team: Thornton D. Hooper and America's First Bombing Squadrons *by Gerald C. Thomas, Jr. The League of World War I Aviation Historians, 1992. 162 pp., b&w photos, $29.95 (hardcover).*

This comprehensive history of the 96th and 11th aero squadrons of the U.S. American Air Service will probably appeal mostly to diehard World War I enthusiasts. Told from the perspective of one aviator, Thornton D. Hooper, the day-

to-day account of squadron activities often becomes tiresome and repetitive, as the activities no doubt were to the participants. The primary aircraft concerned is the American-built DH-4, and claims of its glory are repeated throughout the book. However, historians generally agree that the DH-4 was obsolete by the time the Americans began using them.

For those who are interested in World War I aviation, this book is a welcome respite from the seemingly endless obsession with the well-documented exploits of the Red Baron and Eddie Rickenbacker. But it missed the opportunity to explain the role of the bomber/observation aircraft squadrons, and one wishes the book's scope went beyond the experience of a single pilot.

—Karl Schneide is acting collections manager in the aeronautics department of the National Air and Space Museum.

Eating In: From the Field to the Kitchen in Biosphere 2 *by Sally Silverstone. The Biosphere Press, 1993. 106 pp., color photos, $15.95 (paperback).*

Biosphere 2 is (a) a grand-scale experiment in environmentally prudent living that will prove invaluable to space colonists, (b) a vast glass complex in the Arizona desert where eight members of a spooky cult live, or (c) a very pretty demonstration of recycling. Whichever camp you fall into, you'll have to agree that there's something about the undertaking that arouses strong feeling (see "Trouble in Paradise," December 1991/January 1992). *Eating In*, a book of recipes concocted by the Biosphere's inhabitants, is not going to sway any detractors. Still, it represents a modest but welcome change in Biospherian public relations: it admits to mistakes, disappointments, and unhappy complications. The chickens didn't lay, the pigs ate the chickens, mites chewed up the sweet potatoes, and the bees just died off.

Since the project's rules specify that all food has to be grown on the premises, the book's recipes have a certain...ruggedness. The first ingredient in Biospherian Baked Doughnuts, for example, is "1 medium potato." Many of the dishes are manageable enough with a standard suburban kitchen and a decent grocery store; others are likely to prove a little troublesome, what with ingredients such as "2 or 3 blades of lemon grass." The recipes are both easygoing ("try kiwis or tart apples if guavas are unavailable") and demanding (in a recipe calling for roasted peanuts, the author advises: "Don't use the greasy, salted kind. Buy a bag of raw shelled peanuts and roast them on a baking tray in a 325-degree oven for 20 minutes, turning frequently.") If you're a cook who is game to try flipping a sheet full of peanuts—frequently—you'll get a kick out of this book.

—Perry Turner is the senior associate editor at Air & Space/Smithsonian.

Travel Video

Flying the Bahamas. Ross Gault, executive producer. Island Star Productions, 2225 S.R. 3, Suite 14, St. Augustine, FL 32084; (800) 940-6084. 140 minutes, $53.95.

This is strictly for general aviation pilots—specifically, those who are considering island-hopping in the Bahamas. Having done just that 16 years ago, I was reassured to see that not much has changed. The paperwork for customs and immigration is still ponderous, but the conch, the grouper, and the weather are still well worth the trip.

Narrator Ross Gault filmed the video during six trips he made this year in a twin-engine Piper Aztec. He spends the first hour dispensing lots of helpful advice about flight plans, proper documentation, and required paperwork. Eventually he's ready for takeoff, and it's on to the islands. Along the way he makes more suggestions: in addition to survival gear and life vests, you still need to bring piles of money. Fuel costs are exorbitant (and few vendors take credit cards) and landing fees are ubiquitous. Because flying by visual flight rules is prohibited after sunset, it's crucial that you plan your fuel stops wisely—don't get caught at dusk trying to make it to your next fill-up.

By the end of the two-hour-plus video, you'll feel as if you've seen every runway on every cay in the Bahamas. Despite some occasional amateurish filmmaking techniques, it's a folksy and unpretentious tour that offers plenty of helpful advice.

—Patricia Trenner is the departments editor of Air & Space/Smithsonian.

CALL FOR PHOTOGRAPHERS

Aviation Week's 2nd Annual Aviation and Aerospace Photo Contest

Aviation Week's second annual "Best of the Best" photo contest and special issue will be even bigger and better, bringing together the dynamics of technology and the drama and beauty of flight.

Photographers – professional or amateur – stand to receive the kind of special recognition that comes only to the very few: *Aviation Week's* "Best of the Best" award.

Photos will be judged by an independent panel comprised of the Curator of Art at the National Air & Space Museum, a professional aerospace writer/photographer, *Life* magazine's Senior Picture Editor, and *Sports Illustrated's* Director of Photography.

Selected entries will be displayed in the *Aviation Week* 1993 Photo Issue, with the top three photos (and photographers) in each category to be featured in a special pull-out center section. Winners will be selected in four categories: Civil, Military, Space, plus a General Aviation category that includes hobby, sport, air show and experimental subjects.

New this year is the Editors' Choice Award for those three photographs that best capture a news event or significant aerospace milestone.

Winning photos will be exposed to *Aviation Week's* 500,000+ readers worldwide with contest prizes including: centerform overruns mailed to ad agencies and aerospace marketers; photo displays as major aerospace events; issue and centerform overruns for additional marketing by the winners; participation in *AW&ST's* photo syndication; and more.

Corporate, military, government, freelance or amateur photography shot after October 1, 1992, is eligible.*

Act Now!

Entry deadline for Aviation Week's "Best of the Best" photo contest is October 8, 1993. For official rules, prize information, and entry forms call the AW&ST librarian at 212-512-6013 or fax your request to 212-512-6068.

*Photographs by McGraw-Hill employees or their family members are not eligible.

AVIATION WEEK & SPACE TECHNOLOGY

CREDITS

The Unknown Airman. Norman J. Isler, a former manager at General Electric's Aircraft Engine Group, is now retired and living in Topsfield, Massachusetts, with his wife and daughter.

On a Swing and a Prayer. Donald S. Lopez is the senior advisor to the director at the National Air and Space Museum. His book on his experiences as a test pilot at Florida's Eglin Field will be published next year by the Smithsonian Institution Press.

At the Threshold of Space. Jeffrey L. Ethell has written over 50 books and flown over 200 types of aircraft. He has always considered writing to be the punishment for getting to fly.

Further reading: *Always Another Dawn*, Scott Crossfield, The World Publishing Company, 1960.

The X-Planes graphic supplement.

Further reading: *The X-Planes*, Jay Miller, Aerofax/Orion Books, 1988.

Supersonic Flight, Richard Hallion, Macmillan, 1972.

Reality Check. Frequent contributor William Triplett's most recent article for *Air & Space/Smithsonian* was "An Industry Held Hostage" (February/March 1993).

Into Harm's Way. An occasional contributor to *Air & Space/Smithsonian*, Carl A. Posey flew with NASA's wind shear team while reporting this story. His last article, "Airports Everywhere,"

Shock radio astronomer

"This is a low budget job. Use shorthand."

appeared in the June/July 1993 issue.

Dan McIvor's Mars Mission. Ken Gouldthorpe, a former newspaperman out of Joe Pulitzer's stable in St. Louis, is an editor, publisher, writer, and citizen of the world who found a permanent home in Seattle. He has had an abiding affection for big round-engine World War II aircraft and the men who flew in them ever since he first got airborne in an Eighth Air Force B-24 in 1944.

Flier's Market. John Grossmann, a writer who lives in Jamison, Pennsylvania, is a frequent contributor to *Air & Space/ Smithsonian*.

Davis & Able. A.H. Saxon continues his own heroic service with the U.S. government, working part time as an immunohematologist in the Veterans Administration. He is also the author of numerous books and articles on the circus, theater, and popular entertainments, including a biography of P.T. Barnum (Columbia University Press, 1989).

Further reading: "Able's Dramatic Death and...New U.S. Advances in March to Space," *Life*, June 15, 1959.

Seeking Guidance. Doug Garner is a senior research scientist at NASA's Langley Research Center in Hampton, Virginia. A former controls consultant for the Mercury capsule, Scout space vehicle, and lunar orbiter, he currently works at Langley's flight electronics division.

The Kitty Hawk of Canada. Richard Sassaman lives in Bar Harbor, Maine. He is a great admirer of Bell's, but he still likes to ignore a ringing telephone.

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CALENDAR

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First Annual Rocky Mountain Air Fair. Sponsored by the Rocky Mountain Aviation and Aerospace Association. Colorado Convention Center, Aurora, CO, (303) 367-0670.

Wings in Autumn International Airshow. Courtland Air Base, Courtland, AL, (205) 637-2215.

October 2
Fall Fly Market. Sponsored by Experimental Aircraft Association Chapter 834. Franklin County Airport, Mt. Vernon, TX, (903) 537-2711.

October 2 & 3
66th Annual Parks College Open House and Airshow. Flybys, static displays, exhibits. St. Louis University, Cahokia, IL, (618) 337-7500.

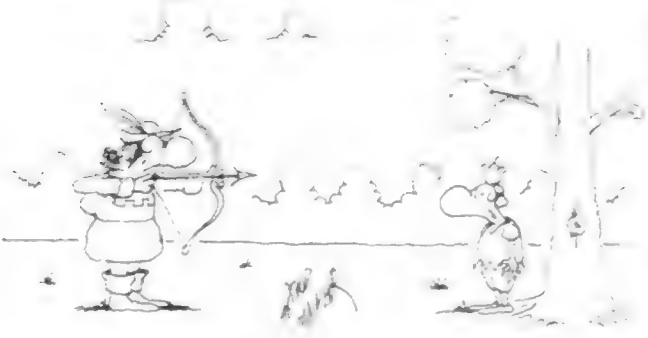
Wings Over East Texas Airshow. World War II and modern fighters, experimental aircraft. Sponsored by the Lone Star wing of the Confederate Air Force. Gregg County Airport, Longview, TX, (903) 759-9491.

October 2–10
Kodak Albuquerque International Balloon Fiesta. Bands, balloon races, flying events, special Mid-Week Mass Ascension. Balloon Fiesta Park, Albuquerque, NM, (505) 821-1000.

October 9 & 10
"Airsho 93." Sponsored by the Confederate Air Force. Midland International Airport, Midland, TX, (915) 563-1000.

1993 International Airshow. U.S. Air Force Thunderbirds, Royal Air Force Red Arrows. Sponsored by the Fort Worth Aviation Heritage Association. Alliance Airport, Fort Worth, TX, (817) 870-1515.

2nd Annual Evergreen Airshow. Team America, Patty Wagstaff, vintage aircraft. Evergreen Air Center, Pinal Airpark, Marana, AZ, (602) 682-4181.



"Have you factored in the probability of wind shear?"

CALENDAR

October 10
Fly-In Breakfast. Sponsored by the Skyhaven Pilots Association. Antique and classic aircraft, displays. Skyhaven Airport, Tunkhannock, PA, (717) 836-4800.

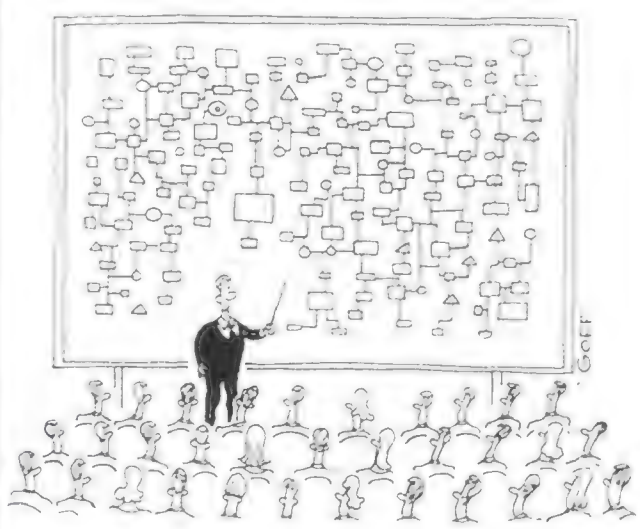
October 16 & 17
9th Annual Wings Over Houston Airshow. Aerobatics with Sean Tucker, Bobby Yonkin, Thunderbirds, Confederate Air Force Airpower Demonstration, air-to-ground battles, static and air displays. Ellington Field, Houston, TX, (713) 531-9461.

October 23 & 24
"Wheels 'n Wings & Interesting Things '93." Event to benefit the Sun 'n Fun Air Museum & Aviation Center. Fly-in breakfast, aerial rally, precision flying, radio-controlled models. Lakeland Linder Regional Airport, Lakeland, FL, (813) 644-0741.

November 4–7
19th Annual Thunderbird Balloon Classic and Airshow. Food, "Hare and Hound" race, live music, balloon acrobatics, children's activities. Glendale Municipal Airport, Glendale, AZ, (602) 978-7208.

November 5–7
"Treasure Hunt in the Sky." Sponsored by the Tucson chapter of the Ninety Nines. The Inn at the Airport, Tucson International Airport, Tucson, AZ, (602) 648-0420.

November 11–13
"A Sleeping Giant Awakens" International Symposium: panels, papers, workshops, speakers. Sponsored by the American Airpower Heritage Museum and Midland College. Confederate Air Force Headquarters, Midland International Airport, Midland, TX, (915) 685-4518.



"And that's why we have no coherent space policy."

"The Satellite Sky" Update/38

These regular updates to "The Satellite Sky" chart will enable readers to keep their charts up to date. Additions can be clipped and affixed to the chart at the appropriate altitude.

New launches

90 to 300 MILES

Cosmos 2258
7-7-93 TT

Resurs F-19
7-22-93 PL

Soyuz TM-17
7-1-93 TT

300 to 630 MILES

Cosmos 2251
6-16-93 PL

NOAA-13
8-9-93 VAFB

Radcal
6-25-93 VAFB

630 to 1,250 MILES

Cosmos 2252-57
6-24-93 PL

6,200 to 13,700 MILES

GPS-21
6-26-93 CAC

21,750 to 22,370 MILES

DSCS-3
7-19-93 CAC

Hispasat 1B
7-22-93 KOU

Insat 2B
7-22-93 KOU

DATA SAUNDERS/KRAMER

Deletions

90 to 300 MILES

Cosmos 2240
down 6-7-93

Eureca
down 7-1-93

Progress M-18
down 7-4-93

Resurs F-2
down 6-20-93

Soyuz TM-16
down 7-22-93

Launched but not in orbit

90 to 300 MILES

Cosmos 2259 CIS photo recon	7-14-93	down 7-25-93
Resurs F-18 CIS earth sensors	6-25-93	down 7-12-93
STS-57 U.S. research	6-21-93	down 7-1-93

Inoperative but still in orbit

300 to 630 MILES

Cosmos 2112

FORECAST

In the Wings...

The Search for Lilya Litvyak. She was one of the first women fighter aces in the world. On her last flight, in August 1943, her group of nine Soviet Yak-1 fighter escorts was overwhelmed by 18 German Me 109s. Her body was found and identified 43 years later, and she was finally recognized as a hero. The writer discovers that in World War II Soviet Russia there were many women like her.

Blundersat. Everything that could go wrong with NASA's new weather satellite program did. When meteorologists order the next set of satellites, will lessons from the GOES Next mess be heeded?

Combat Comics. Terry and the Pirates, Buz Sawyer, Barney Baxter, and Smilin' Jack were among the most famous pilots of World War II, whether their comic strip creators had them fly in beautifully rendered P-51s or bizarre fighter-bombers found only in the funny pages.

Test Pilot on Skis. A memoir by the late Milton O. Thompson describes the trouble pilots could get into at Edwards Air Force Base when winter rains kept them from flying the X-15.

A Flight for Family. Last December a Cuban defector flew from the Florida Keys to his former home in a Cessna 310, landed the airplane on a highway, grabbed his wife and children, and fled back to the United States. His desperate rescue took careful planning, inside knowledge of the Cuban air defense system, and a fighter pilot's skill.

The Kitty Hawk of Canada

The staff at the Alexander Graham Bell National Historic Site in Baddeck, Nova Scotia, has a problem: some visitors just don't give the museum a fair chance. "No matter how many times we tell them," says guide supervisor Arlene Morrison, "some people get to the end of the first area and leave, thinking they've seen the whole museum."

It's an understandable mistake. The first section, Teacher and Inventor Hall, showcases Bell's most famous accomplishment—his 1876 invention of the telephone. But visitors who continue down a corridor to Experimenter's Hall will find much more of interest, including a display entitled "Kites, Strings, and Whirling Things," which documents Bell's role as a pioneer of aviation.

The museum is well positioned to show Bell's post-telephone accomplishments. The town of Baddeck, located on Cape Breton Island, became Bell's home away from home after he passed through it in 1885, while touring Canada with his wife Mabel and their two daughters. Over the years he bought a total of 600 acres in the area as a summer retreat. His descendants still vacation at the Baddeck estate he named Beinn Bhreagh ("ben VREE-ah"), Gaelic for "beautiful mountain."

Bell had long been interested in flight, but it wasn't until he moved to Beinn Bhreagh that he was able to pursue his ideas. The museum's artifacts give visitors a sense of the breadth of Bell's imagination: included are everything from a series of rockets the inventor had built, ranging in length from roughly eight inches to eight feet, to catapult launchers for firing large wedge-shaped "darts."

Bell was also interested in manned flight, especially via kite. A sufficiently sturdy one, he wrote, could be equipped with propellers and an engine, producing "a practicable flying machine." Looking for a structure suitable for either kites or airplane wings, Bell settled on the tetrahedron, a pyramid in which three triangles form the sides and a fourth triangle forms the base. These shapes, Bell found, could be clipped together and easily mass-produced. The museum pays tribute to the design by hanging a variety of tetrahedral kites from the ceiling in the first hall. And the A-frame shape of the museum itself, with triangular windows at each end, also celebrates the style.

In 1907 Bell brought together four young flying enthusiasts, two Canadian and two American, and the five friends formed the Aerial Experiment Association. The Canadians were Baddeck local J.A.D. McCurdy and a Toronto classmate, Frederick "Casey" Baldwin; the Americans were Glenn Curtiss, known then as a motorcycle racer and engine designer, and Thomas Selfridge. The AEA's first creation was the Cygnet I, a 3,393-tetrahedron kite that Bell designed. In December 1907 Selfridge flew the 42-foot-wide structure to an altitude of 168 feet.

The group quickly went on to build four airplanes. Working in Baddeck and in Hammondsport, New York, near Curtiss' machine shops, the AEA members took turns designing and flying the airplanes, all of which made history. Piloting the *Red Wing* in New York on March 12, 1908, Baldwin became the first Canadian to fly. Two months later, Selfridge made two hops in the *White Wing*, becoming the first U.S. Army officer to fly an airplane. On the fourth of July, Curtiss flew the *June Bug* 1.1 mile, winning a $2,500 trophy from *Scientific American*. The next year, McCurdy and the *Silver Dart* made the first airplane flight in Canada.

Because Bell's invention of the telephone had entangled him in hundreds of patent lawsuits, he became a compulsive documenter, using both notebooks and photographs to record his many inventions and designs. Consequently, the museum has an abundance of photographs on display, including many showing the AEA's airplanes at different stages: construction, maiden flights, and, in some cases, crashes. The collection also includes actual airplane hardware (some prototypes, some from the AEA craft): a Gnome and two Liberty engines, various instruments and gauges, wheels, radiators, and an assortment of Bell-designed propellers, including wood, metal, and cloth-over-frame varieties.

The AEA didn't last long. In September 1908 Selfridge became aviation's first fatality when the airplane he was riding in, piloted by Orville Wright, crashed. Then Curtiss grew interested in commercial ventures in the States. The group disbanded in March 1909. That year, Bell, Baldwin, and McCurdy formed the Canadian Aerodrome Company, Canada's first aircraft manufacturer, which produced biplanes named Baddeck Number 1 and Number 2.

Beyond Experimenter's Hall, visitors will find Hydrofoil Hall, containing a reconstruction of the HD-4 boat, which Bell had built in later years. In 1919 it attained a speed of 70.86 mph, becoming the world's fastest boat. Also displayed are the remains of the original hull.

For all his enthusiasm for flying, Bell never did try it for himself. He was 60 years old when the AEA began its experiments, and perhaps he felt it best to leave the flying to the younger members. But one of the museum's artifacts, not presently displayed, hints at the inventor's fantasies about the exhilaration of flight. According to Aynsley MacFarlane, chief of visitor activities, Bell had a model airplane built of wood, paper, and metal, complete with a tiny pilot. Once the model's propeller is set in motion, every half-dozen rotations the pilot doffs his hat. His profile, MacFarlane adds, is strikingly similar to Alexander Graham Bell's.

—Richard Sassaman

Alexander Graham Bell National Historic Site, P.O. Box 159, Baddeck, Nova Scotia, B0E 1B0 Canada. Located on Route 205 at east end of Baddeck. Phone (902) 295-2069. Open 9 a.m. to 5 p.m. daily, October through June; 9 a.m. to 9 p.m. daily, July through September. Admission free.

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The X-Planes

A guide to aviation's most extraordinary test program

AIR&SPACE
Smithsonian

A supplement to the October/November 1993 issue of *Air & Space/Smithsonian*

[#] number built; one unless noted

Bell X-1 [3]
First powered flight December 3, 1946.
Explored transonic and low supersonic speed envelope. On October 14, 1947, XS-1 (Experimental Sonic) became the first aircraft to exceed Mach 1.

X-1

Bell X-1A, 1B, 1D
First powered flight of 1A February 21, 1953; of 1B October 8, 1954.
Investigated aerodynamic phenomena at speeds above Mach 2 and altitudes above 90,000 feet.

X-2

X-3

Bell X-1E
First powered flight December 15, 1955.
Assessed performance improvements with extremely thin wings and more efficient engine turbopump.

X-4

Bell X-2 [2]
First powered flight November 18, 1955.
Explored transonic and Mach 3 performance of swept-wing design and studied aerodynamic heating.

Douglas X-3
First flight October 20, 1952.
Intended to explore Mach 2 speeds with a jet engine.

X-5

Northrop X-4 [2]
First flight December 16, 1948.
Tested semi-tailless (no horizontal stabilizer) configuration at transonic speeds.

X-6

Bell X-5 [2]
First flight June 20, 1951.
Investigated variable-sweep wings.

Convair X-6
NB-36H made the first flight with an operating one-megawatt reactor on September 17, 1955.
Intended to evaluate practicality of 165,000-pound nuclear propulsion system. Program was canceled before prototype was constructed.

X-7A

X-8

Lockheed X-7 missile family
First launch April 26, 1951.
Tested supersonic ramjet propulsion.

Aerojet General X-8 Aerobee missile family
First launch November 24, 1947.
Evaluated payload recovery system for an inexpensive sounding rocket.

X-9

X-10

Bell X-9 missile
First launch May 17, 1950.
Assessed feasibility of air-to-surface nuclear missile.

North American X-10
First flight October 14, 1953.
Tested aerodynamics and navigation hardware for upper-stage cruise component of Navaho missile; later a nuclear cruise missile candidate.

X-11

X-12

Convair X-11 rocket
First launch June 11, 1957.
Single-stage ballistic rocket that evaluated hardware and performance of Atlas intercontinental ballistic missile; also tested the Atlas' sustainer rocket engine.

X-13

Convair X-12 ballistic test vehicle
First launch July 9, 1958.
1.5-stage rocket-powered ballistic vehicle that tested the systems and hardware for the production version of the Atlas ICBM.

X-14

Ryan X-13 [2]
First flight December 10, 1955; first hover May 28, 1956.
Investigated jet-powered vertical-takeoff-and-landing capabilities of the "tailsitter" design.

Bell X-14, 14A, 14B
First flight February 17, 1957.
Researched vertical takeoff and landing using vectored jet thrust.

X-15

North American X-15, 15A-2 [3]
First powered flight September 17, 1959.
Explored hypersonic (Mach 5+) upper atmospheric and spaceflight (250,000 feet).

X-16

Bell X-16
Conceptualized 1952; not built.
High-altitude long-range reconnaissance rival to U-2.

X-17

Lockheed X-17 rocket
First launch July 17, 1956.
Tested reentry nosecone designs with multi-stage rocket.

Hiller X-18
First flight November 24, 1959.
Assessed feasibility of large tilt-wing vertical takeoff and landing craft.

X-18

Curtiss-Wright X-19 [2]
First flight June 26, 1964.
Demonstrated tilt-rotor vertical-takeoff-and-landing configuration with propellers used for lift during transition from hover to forward flight.

X-19

Boeing X-20
Contracted 1959; not built.
Piloted delta-wing glider named Dyna-Soar (Dynamic Soaring) intended to conduct experiments in hypersonic and orbital (Mach 16 to 18) flight regimes and test reentry and landing characteristics.

X-20

Northrop X-21A [2]
(Converted Douglas B-66s)
First flight April 18, 1963.
Explored feasibility of using full-scale laminar flow control on large subsonic swept-wing aircraft.

X-21A

Bell Aerospace Textron X-22A [2]
First flight March 17, 1966.
Tested dual tandem ducted propellers for vertical takeoff and landing.

X-22A

Martin Marietta X-23A [4]
First flight December 21, 1966.
Tested the feasibility of an unmanned hypersonic lifting-body reentry vehicle.

X-23A

Martin Marietta X-24A, 24B
First powered flight March 19, 1970.
Explored low-speed flight characteristics of a manned lifting body.

X-24B

Bensen X-25, 25A, 25B
First flight June 5, 1968.
Explored a maneuverable ejection and descent system based on the Bensen homebuilt autogiro.

X-25A

Schweizer X-26A/Lockheed X-26B [6]
First flight X-26A July 3, 1962.
Stealth observation and sensor system craft for intelligence gathering in Vietnam. A highly modified powered sailplane.

X-26B

Lockheed X-27
Proposed 1971; not built.
Supposedly intended to test advanced technology for the next-generation lightweight fighter but actually a Skunk Works project for an upgraded F-104 export fighter masquerading as the CL-1200 Lancer. Lost out to Northrop F-5E Tiger II.

X-27

Pereira X-28A
First flight September 16, 1971.
Modification of existing homebuilt Osprey seaplane. Single-place "Air Skimmer" seaplane evaluated for civil police patrol in Southeast Asia.

X-28A

Grumman X-29 [2]
First flight December 14, 1984.
Tested forward-swept wing and advanced composites.

X-29

X-30
Announced 1986.
Canceled prior to construction.
Hypersonic transatmospheric vehicle testbed (National Aerospace Plane) in supersonic-combustion ramjet (scramjet)-powered lifting body configuration.

X-30

Rockwell/Messerschmitt-Bölkow-Blohm X-31A
First flight October 11, 1990.
Evaluated potential of vectored thrust to allow close-in aerial combat beyond normal angle of attack.

X-31A

Though not part of the X series, these research aircraft provided invaluable data.

Douglas D-558-1 Skystreak [3]
First flight April 15, 1947.
The Navy's D-558-1 explored transonic and supersonic speeds as a turbojet-powered backup to the rocket-powered X-1.

Douglas D-558-2 Skyrocket [3]
First flight February 4, 1948.
Investigated swept-wing performance with combination turbojet and rocket engine. Converted to all-rocket propulsion in 1950. On November 20, 1953, the D-558-2 became the first aircraft to exceed Mach 2.

Convair XF-92A
First flight September 18, 1948.
Investigated transonic performance of thin delta wings. Inspired the F-102/F-106, XF2Y, and B-58 families.

Douglas X-3
The aptly named Stiletto, which was to explore extended flight at Mach 2 with a jet engine rather than a rocket, was a disappointment as a research vehicle due to insufficient engine performance. Nevertheless, it furnished important information on control problems associated with high-speed flight. Because it usually landed at high speeds, it regularly blew tires; solving that problem contributed to aircraft tire technology.

Grumman X-29
Though the potential of forward-swept wings to decrease drag and increase agility was explored in Germany during World War II, it was not until the advent of composites that a wing could be constructed with the strength to withstand the ultimate aerodynamic forces that act on such a structure. The X-29, a forward-swept-wing evaluator, emerged after a 13-year hiatus in the X-plane program. Its inherently unstable design relies on three computers to ensure stability—a total electrical failure would render the aircraft instantly uncontrollable.

North American X-15
The X-15, which proved that high-speed, high-altitude manned flight was feasible, is generally regarded as the most successful of all the X-planes. It holds the altitude record for aircraft—314,750 feet—as well as an unofficial record of 354,200 feet, and it reached a speed of Mach 6.7 (4,520 mph). The aircraft had conventional controls for atmospheric flight and reaction control rockets for flight above 100,000 feet. Eight pilots flew the X-15 high enough to qualify for astronaut wings.

Bell Aerospace Textron X-22A
The ungainly X-22A, with its ducted-fan propulsion system, proved to be a nimble vertical-takeoff-and-landing demonstrator. Forward flight was achieved by slowly rotating the ducts to the horizontal while allowing the aft-mounted airfoil and the ducts to develop lift.

Ryan X-13
Built to explore the feasibility of a vertical-takeoff-and-landing jet fighter, the X-13 was secured to a flatbed trailer that was raised to the vertical for takeoff. When takeoff power was achieved, the pilot would disengage the aircraft's nose hook from a horizontal cable strung across the top of the trailer; during landing, the pilot approached the trailer in a vertical hover and engaged the cable. The pilot's seat rotated forward for takeoff, landing, and hovering.

Design and production by
Phil Jordan and Julie Schieber
Illustrations by John Batchelor

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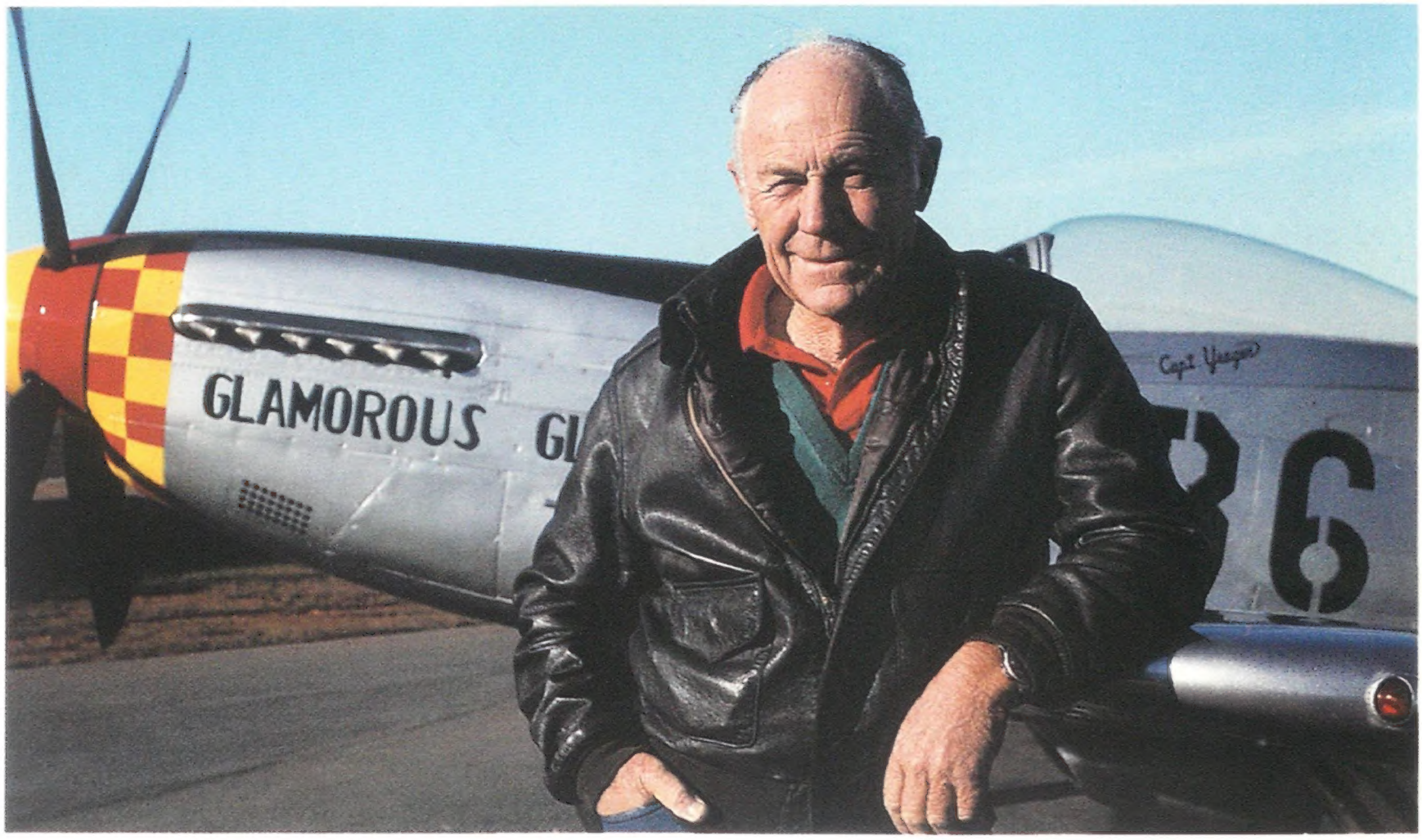


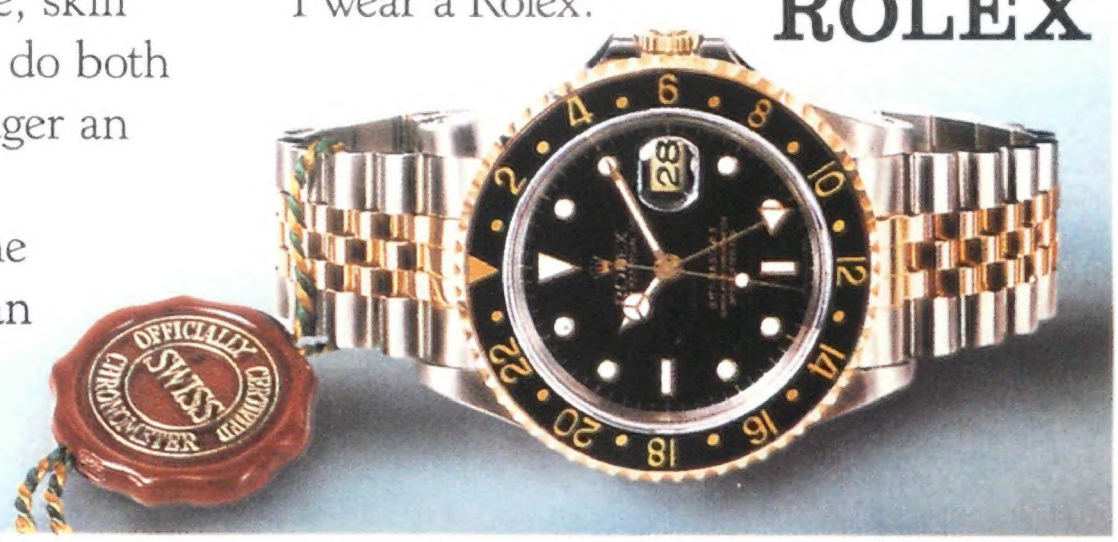
"If you want to grow old as a pilot, you've got to know when to push it, and when to back off." *Chuck Yeager*

Throughout his remarkable career, Chuck Yeager has shown an uncanny talent for what pilots call "pushing the edge of the envelope." At 21, only three years after boarding his first plane, Yeager was leading a squadron of fighter pilots in World War II. And at the age of 24, he became the first person to fly faster than the speed of sound.

Attempting such dangerous feats is one thing. Living to describe them to your grandchildren is another. Displaying the enormous courage, skill and cool judgment needed to do both has made General Chuck Yeager an authentic American hero.

Although retired from the military, Yeager remains a man on the move. He's an avid sportsman with a lifelong love of the outdoors, a lecturer and a consulting test pilot who still loves to fly. "Maybe I don't jump off 15-foot fences anymore," said Yeager, "but I can still pull 8 or 9 G's in a high-performance aircraft." And in all his exploits, Yeager depends on a rugged and reliable timepiece. "I wore a Rolex 40 years ago when I broke the sound barrier and I still do today," says Yeager matter-of-factly. "A pilot has to believe in his equipment. That's why I wear a Rolex."

ROLEX



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